Vol. 3, No. 2 AUGUST, 1916

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

CONTENTS

THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: Sub-Station 84

Single Number, 30 Cents Yearly Subscription, $3.00

THE SCIENTIFIC MONTHLY

AUGUST, 1916

CHANGING CONDITIONS IN THE KENTUCKY MOUNTAINS[1]

By B. H. Schockel

STATE NORMAL SCHOOL, TERRE HAUTE, IND.

THIS summary of changing conditions in the plateau of eastern Kentucky is based upon a month's field work, supplemented by previous and subsequent studies. The order of treatment is as follows: an introductory view of the topography, surroundings and settlement; the changing conditions with respect to the chief natural resources; manufacturing, transportation; the people, with reference to their numbers, distribution and condition, their institutions, and their customs and habits; the future.

Topography and Surroundings

Eastern Kentucky is a part of the Cumberland Plateau, and consists of 35 counties with an area of some 12,943 square miles, that is, about one third of Kentucky. It is a part of the Southern Appalachian Highlands. To the east of it are the parallel ridges and valleys of the Greater Valley of the Appalachians; to the west is the Blue Grass region. The top of the plateau was an old plain with low hills on it (a part of the Cretaceous Peneplain, with monadnocks) and sloped gently westward in Kentucky from an elevation of about 2,000 feet to a height of 1,200 to 1,500 feet. Since then this plain has been so thoroughly dissected by streams, in pattern like the branches of a tree, that probably not more than 4 per cent. of the land is level (topographic stage of mature erosion by dendritic drainage), the valleys being from 500 to 800 feet deep with narrow bottom lands, and the tops of the ridges averaging in many instances from 10 to 50 feet in width. The ridges, locally known as mountains, in general bear on their shoulders and crests hardwood forests sprinkled with conifers. Most of the lower slopes are cleared. From the top of Pine Mountain the Kentucky country appears to be a billowy wilderness. One can not see any valleys nor any sign of life; but beneath those forested waves are sylvan slopes to enchant one, and a sinister labyrinth of gashed valleys to grip one in mountain poverty.

[1] Illustrations by the author.

Owing to the topography the roads are serpentine; since the bed rock is of shale and friable sandstone chiefly, good road material is scarce; furthermore, the people are poor, and what we thoughtlessly term shiftless and ignorant; therefore, their highways are in a most wretched condition.

FIG. 1. BIRD'S-EYE VIEW OF THE KENTUCKY MOUNTAIN REGION, based upon the Kentucky Geological Survey and the topographic maps of the U. S. G. S. The extent of Pine Mountain shown is about 90 miles. The key to the map follows: 1, Blackie; 2, Buckhorn; 3, Cumberland Gap; 4, Cumberland Mountain; 5, Cumberland River; 6, Greasy Creek; 7, Hindman; 8, Jenkins; 9, Levisa Fork, Big Sandy River; 10, Line Fork; 11, Middlesboro; 12, Middle Fork Kentucky River; 13, North Fork Kentucky River; 14, Oneida; 15, Pine Mountain; 16, Pine Mountain Postoffice; 17, Pineville Gap; 18, Pound Gap ("Trail of the Lonesome Pine"); 19, Prestonburg; 20, Red River; 21, South Fork Kentucky River.

SETTLEMENT

In the sixteenth century, James I. introduced Scotch settlers into northern Ireland, who became the Scotch-Irish. Some of them emigrated to America; and their descendents, augmented by English, native

Irish, Pennsylvania Dutch, and others, formed the van of the 300,000 frontiersmen who passed through Cumberland Gap, 1775–1800, to settle in Kentucky.

Some of these found a home in the plateau region, which offered clear springs, magnificent forests, abundant game, and good valley land sufficient for that first generation of hunter-farmers. No one could have foretold then the coming of canal and railroad.

The first permanent settlements in the Kentucky mountains were made in the decades 1780 to 1800. Filson's map of Kentucky (1784) shows "settlements" on Rockcastle River, the Upper Louisa Fork, and a fork of Red River. By 1800 the population was 7,964, which was about four per cent. of the population of the state; it is now about 600,000, which is about twenty-five per cent. of Kentucky. Genealogical records of this people are utterly lacking. Their names and survivals in customs and language point to English and Scotch-Irish ancestry in general, although a few German and Huguenot names are found.

Between 1800 and 1840 the mountain region was an integral part of the state for various reasons. Four interstate, transmontane routes traversed the plateau in leading from the Ohio and the Blue Grass settlements on the west to the Big Sandy and Kanawha region on the east, and thus on to the tide-water communities. The plainsmen bought lean cattle in the Blue Grass and sent them in droves of from 200 to 300 through the mountains to the Potomac, where they were fattened and sold in Baltimore and Philadelphia. Large droves of hogs followed the same routes. Furthermore, the hog and cattle drivers bought corn at the homes of the mountain people and brought news from the outside world, thus binding the Kentucky people somewhat closely together. Also, because the Kentucky interstate commerce passed through the mountains, the slender state appropriations for roads were impartial, the mountain counties being favored equally with the lowland.

But between 1830 and 1850 the four interstate roads declined gradually to a wretched condition and state of non-use; for the Blue Grass and Ohio regions were finding other routes to market, by use of steamboats, etc. Therefore the mountain counties lost their market and received little outside help for roads. As a result, these peoples, who have never been able to travel freely among themselves within their mountains, have since about 1845 suffered the further handicap of being cut off from the outside world, and have lived in surprisingly complete isolation. Presently the civilization of the rest of the Americans changed, and they became "foreigners" to the mountain folk. Thus the mountaineers have lived isolated by topography and social antipathy.

During the civil war thousands of the mountaineers, whose ancestors had fought in the revolution and the war of 1812, joined the Union army and received a practical education. Some received similar train-

FIG. 2. SOUTH FORK KENTUCKY RIVER NEAR BOONEVILLE.

ing as soldiers of the south. After the war many returned home. But the growth of the formal education and the broader outlook, both of which were stimulated by the war, has been slow.

In 1878, Shaler, of the Kentucky Geological Survey, saw in the eastern, and then most inaccessible portion of the region, men hunting squirrels and rabbits with old English "short-bows" and wrote:

> These were not the contrivances of boys of to-day but were made and strung, and the arrows hefted, in the ancient manner. The men, some of them old, were admirably skilled in their use; they assured me that, like their fathers before them, they had ever used the bow and arrow for small game, reserving the costly ammunition of the rifle for the deer and bear.

Recently outside capital has begun to develop the coal and timber resources of the region, a fact which is bringing about many changes in the mountain country, and that rapidly. As a result, the inhabitants are facing the crisis brought about by the sudden mingling of a primitive people with the exploitative phase of modern civilization.

CHANGING CONDITIONS

We shall now turn to the changing conditions within the mountains, and consider the natural resources, first of all, the mineral wealth.

Mineral Resources

At an early period iron and salt within the region were the source of considerable traffic, but not now. Oil, gas and clays, although in progress of exploitation for the past two decades, do not promise to become important.

Coal is the chief mineral resource of the region. The seams occur in every county, increasing in number and thickness towards the south-

east and reaching their climax in the Black Mountain region. The layers are favorably disposed for mining, except in the Pine and Cumberland mountains, where complex structure renders mining difficult. The coal is bituminous, the most desirable varieties being as follows: Cannel, found in limited basins throughout the field; coking, appearing in large amounts only in the vicinity of Pound Gap; and high-class steaming coals, occurring in quantity in the southeastern counties and at a few places along the western margin.

Coal was exported in 1827, probably earlier; but until the railroad came, the output was insignificant. Though production is rather small at the present time, and limited to a few mines scattered along the railroads, the region is beginning to become an important coal center.

The first extensive exploitation began in the region about Middlesboro, in 1892. At present most of this coal is shipped south. Some two years ago a branch of the L. & N. railroad was pushed up the North Fork Kentucky River to Hazard, and extensive coal mining began. Hazard is now (1915) in its ugly duckling stage, has a population of about 2,000, boasts one of 3,500, and altogether is a scar upon the beautiful landscape, like a "boom" town of the west. But the most spectacular development is taking place at Jenkins, on the headwaters of Elkhorn Creek, at the foot of Pound Gap, Pine Mountain, known in literature as "The Trail of the Lonesome Pine." Eighteen months ago a branch of the B. & O. railroad reached the site, where a few months prior there had been but one mountain cabin. Jenkins now has brick buildings three stories high; a great power plant; palatial residences; a splendid hospital; a concrete dam causing an artificial lake, upon which are pleasure boats; and a town reservoir, into which spring water is filtered from the mountain. Indeed it is growing as fast as Gary,

FIG. 3. CUMBERLAND GAP.

FIG. 4. FARMS AND FOREST NEAR BOONEVILLE.

Indiana, in its early days. Most of this coal is shipped across Indiana to Gary.

Forest Resources

The virgin forests were splendid. But since an early day, lumber has been shipped to an outside market; therefore the timber area has been reduced, and, although it remains the chief source of wealth, the end is almost in sight. About thirty per cent. of the region was in wood in 1910, not all of which was primeval.

The mountaineer's way of lumbering is to cut a few choice trees and "snake" them down to the creek, where, as logs, rafts or railroad ties, they await the coming of the flood, or "tide," to be floated down stream. Thus a man can produce ten ties per day, for which this summer, near Beattyville, he received thirty-eight cents apiece. But lumbering corporations are beginning to attack the two remote corners of the Southern Appalachian Highlands, the Smoky Mountains and the Kentucky Plateau; and after the onslaught, in which stumps three and one half feet in diameter are left to rot, the hills are gaunt with slash, or black from resultant forest fires. Consequently increased erosion is resulting on the slopes, with augmented harmful deposition on the flats below. Furthermore, within and below the plateau, the streams increasingly are characterized by short periods of flood, and long intervals of low stage. Also, the supply of drinking water and water power is becoming less constant.

Most of the timber is owned by outside capital. The United States government is seeking to buy wooded land for forestry, having completed the first step in 1914, when it purchased the 60,000 acre Biltmore estate, near Asheville, N. C.

A passing forest industry is the digging of ginseng and other roots.

The normal market price for the first is five dollars to seven dollars per pound, but now, owing to the war, the price has fallen. I came upon one old man and his wife, digging "sang" in the woods, who stopped to talk for an hour and wanted to know why it is that the Chinese can not live without the root, and what would happen to that people when the supply shortly would give out in America, but who then consoled themselves with the thought that probably the Chinese have enormous amounts of it stored away in anticipation.

Animal Resources

Wild game is becoming surprisingly scarce, due to over hunting and lax observation of hunting laws. In general the supply of fish is low, some causes being: Dynamiting and seining, lack of restocking, and inconstant and turbid streams resulting from deforestation. What little meat is eaten is chiefly swine and chicken. Sheep continue to suffer from exposure and dogs, and are decreasing in numbers. Beef is walked to market to obtain cash with which to pay taxes. Cattle raising is becoming more important. The Ayrshire stock is giving way to a fine short-horn type of cattle, owing to the opening of stockyard cattle markets, as at Mt. Sterling. The mountain mule and pony are being displaced by larger types. Mules are increasing, while horses are decreasing. Goats suffer from the rough, wet, winter climate.

The development of pasturage for live stock would prove to be a lasting advantage. Timothy is the chief forage crop; clover is second. A diminutive Japanese clover has filtered into the mountains, and takes possession of deserted fields. It is good for grazing, but it is too small to be cut.

Fig. 5. Logs awaiting High Water, "High Tide," in the South Fork Kentucky River, near Oneida.

Agriculture

About 80 per cent. of the land is in farms, of which 45 per cent. is improved, and 23.5 per cent. in woodland. The average size of the farm is 85.7 acres, of which about 39 acres are improved (Kentucky, 85.6, 55.4; Indiana, 98.9, 78.6). Twenty-four and a half percent. of the farms range in size from 50 to 99 acres; 19 per cent. from 100 to 174 acres; and 18.5 per cent. from 20 to 49. The average value of all crops per farm in 1910 was $310.70 (Kentucky, $536.20; Indiana, $947.60). The average value of implements and machinery per farm in 1910 was $32.3 (Kentucky, $80; Indiana, $190). About 6.6 cents worth of fertilizer was used per improved farm acre in 1909 (Kentucky, 8.7; Indiana, 12.8).

The total value of all crops in 1909 was 24.8 million dollars, of which cereals amounted to 12.2 million, vegetables 3.8, hay and forage 1.1, and fruits and nuts 1.1. The total area in cereals was 921,538 acres, of which corn constituted 841,744 acres; oats, 39,341; wheat, 36,403; rye, 1,579; and barley, 510. Some 21,397 acres were devoted to potatoes, 5,673 to sweet potatoes and yams, and 10,713 to edible beans (a staple food in the mountains). Sorghum was raised on 21,970 acres, and hay and forage on 162,944 acres. There were 1,825,895 apple trees out of a total of 2,425,047 fruit trees. Peaches ranked second to apples.

The average production of corn per acre in 1909 in the region was 18.7 bushels; in Kentucky, 24.2; in Indiana, 40. The corresponding figures for wheat were 9.9; 12.8; and 16.3. Similar data for potatoes were 76.6; 91.8; and 99.4. The respective figures in tons of forage per acre were .8; .9; and 1.2.

The shale soil, which is most common, is fairly fertile, and produces good crops of corn under good cultivation, on gentle slopes. The chief causes for the low productivity are steep slopes, poor cultivation and lack of crop rotation. The shale soil washes less than almost any other soil under like circumstances. The wonder is that the soil produces as much as it does.

A few years ago Berea College, with the help of the United States government, employed a special investigator and demonstrator to work with the mountain farmers within reach of Berea. The success was such that a number have been appointed in other localities. About Berea, heavy breaking plows are replacing the one-mule plow, and the disk harrow is appearing in the mountains. More than twice as many shallow cultivators as single-shovel and double-shovel plows were sold in Berea last spring. The practise of sowing cowpeas and rye for forage and turning under is spreading, as is the use of commercial fertilizer. Crop rotation is displacing the fallow system.

Further education in agriculture is being given at the missionary and settlement schools, as at Oneida, Hindman, Buckhorn and Blackie.

But agriculture in the interior of the region is yet primitive, and improvements are slow in penetrating. A common sight is corn growing among girdled trees.

The few truck gardens which are being introduced about the settlements and mining and lumbering camps are giving favorable results. Of course, each farm has its little garden for home use.

Naturally, the region is a splendid fruit country, especially for apples; but spraying is unknown, and the stock has degenerated. Therefore the trees bear abundant crops of gnarled, sour fruit. One mountain woman told us to take as many apples as we wished, since they were of no value except to sharpen the teeth on. Often apples are sold for ten cents per bushel, are given away, or rot, on account of poor transportation.

Manufacture

Turning now to manufacturing within the region, we note that it always has been meager, primitive and for local use, except in the case of salt in the early days.

In 1901 Bell and Boyd counties contained 172 manufacturing establishments, with an aggregate capital of $5,201,489, an amount which was more than one half of that invested in manufactures in all the thirty-five counties in 1910. The cause for the emergence of these two counties is the recent growth of Ashland and Catlettsburg on the Ohio River, and Middlesboro near Cumberland Gap, a local supply of coal being the factor in each case. Hazard and Jenkins soon will rank as manufacturing cities.

The status of manufacturing for 1900 is indicated in the following table:

	Establishments	Cap. Per Establish.	Men 16 Yrs. and Over	Women 16 Yrs. and Under	Children Under 16	Capital	Value of Products
Kentucky Mts.	1,156	$7,221	4,853	44	85	$ 8,347,993	$ 11,993,195
Kentucky	9,560	10,886	51,101	9,174	2,687	104,070,791	154,166,365

The mills are small and driven in general by water, animal, and hand power. Machine-made goods from the outside have supplanted the linsey-woolsey cloth, counterpanes and baskets made in the cabins. But, recently, the missionary and settlement schools have begun to sell such goods outside of the mountains for the people, to supply cash, and therefore the industries are reviving, in part. The W. C. T. U. Settlement School at Hindman, for example, sold $1,800 worth of such goods in 1914.

Distilling always has been a widespread industry in the mountains, since thereby corn, the chief crop, is converted into a product which can be marketed with profit, and since the custom has been inherited. Illicit

distilling increased greatly after the imposition of the liquor tax of the Civil War. In 1877 the government began to suppress "moonshining" in the region. By 1882 the supremacy of the law had been established. But in 1894 the liquor tax was increased from ninety cents to one dollar and ten cents, which resulted in increased "moonshining." The counties have been voted "dry," which encourages the illicit traffic. About the coal-mining centers, "blockading" is increasing greatly, the whiskey being brought to town under vegetables and in milk cans. Our mountain guide in the saddle of Pound Gap pointed down the "Trail of the Lonesome Pine," saying: "We can go right down there into Virginia and get all the spirits we want. I know where there is a still less than a mile away. There are a lot of 'em stuck 'round hereabouts in the rocks and the mist." One morning a strange young man, not from

FIG. 6. MOUNTAIN FARM, AND HOME WITHOUT WINDOWS.

Kentucky, boarded our train at a small station not far from the land of "Kingdom Come" and "Hell fer Sartin," and became my seat-mate. He had dark circles about his eyes, and otherwise looked tired. As he did not inform me as to his identity it is safe to recount his story. He gained the confidence of a mountain man and received a letter of introduction, which he presented to a second mountain man after walking some twenty miles up a certain creek. This man kept the letter, took him up a side branch and turned him over to a third mountaineer. This one led him to a cove and told him to "go straight ahead!" which he did. Presently he was standing in the door of a "moonshine" still, and three men faced him, their revolvers on a rude bench. After stating that his business was merely one of curiosity, and after answering a host of questions put sharply, he was required to drink some of the liquor. Then he remained with the men for an hour, talking with them and watching them at work. Upon leaving he was offered a gallon of

liquor for friendship's sake. But he could not carry that much; therefore they put a quart bottle into his pocket, telling him "Good-bye! Whinever you want some good liquor, or your friends, let us know. We make pure stuff. No 'dultering here." He stumbled along until about eight o'clock that night and came to a mountain town of twenty houses, having covered thirty-five miles that day. The story concerning the night and the next morning will not be told, lest it cause resent-

Fig. 7. A "Deadening" Cornfield of an "Upright" Farm.

ment in that little town. Now it had happened that three days before, my comrade had lost, in this same general vicinity, a purse containing in all $110, whereupon we had trudged back down a mountain and had found the finder, who had gladly restored it to us, and indeed, who had told several people of his discovery, thus hoping to find the owner. Therefore I was in no mood to judge the "moonshiners" harshly, even though the quart bottle was shown to me.

Transportation

I wish I could adequately emphasize the fact that transportation is the basic problem of the region. Poor communication within it h

influenced greatly every phase of life always, and bad connections with the outside have isolated the country since 1850. Of a total of 17,432 miles of road, there were within the entire region, in 1904, 83 miles surfaced with stone, and four miles with gravel. The present wagon freight is said to be about 44 cents per ton-mile. The average haul for a load of cross ties is from eight to ten miles, and about eight to twelve ties constitute a load. Logs delivered at the railroad for twenty dollars

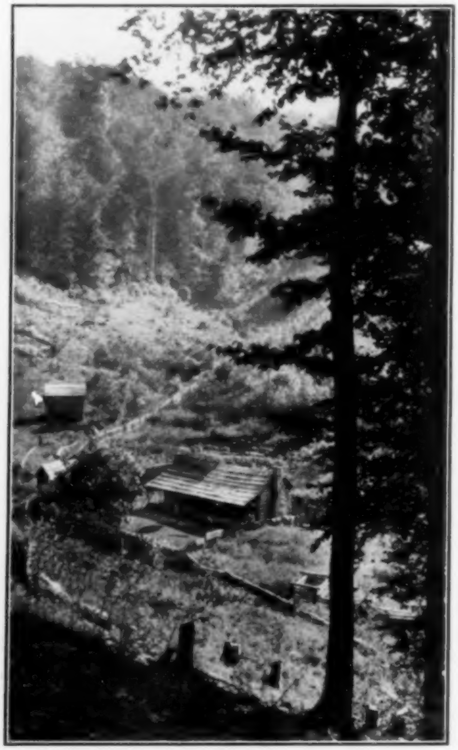


FIG. 8. A PRIMITIVE MOUNTAIN HOME, NEAR BUCKHORN. THE TOP OF THE "MOUNTAIN" IS ABOUT 500 FEET ABOVE THE HOUSE.

per load are said to consume sixteen dollars in transportation. At a coal shaft mined by two mountaineers near Boonville, good cannel coal sells for seven cents per bushel. The cause is poor transportation. From Buckhorn to the railroad is eight miles. A team will make this trip for four dollars in good weather. The charges in this case are about 88 cents per ton-mile. The average cost of transportation in the United States by wagon is 23 cents per ton-mile.

The old law that every man must work on the roads six days annually is enforced feebly. By a statute passed in 1894, road taxes can be levied by the county and a road commissioner appointed. But this new

law is proving a failure in the mountains and is giving way to the old custom because the mountain county is too poor to pay the commissioner's salary, and because the mountain man may pay the tax in work, a fact which introduces again the old problem of road-work enforcement. Our venerable host at Booneville, formerly a judge, although deploring greatly the lack of education in his county, insisted that the most pressing need of his people is an outlet for their produce. "It used to be thirty miles to the railroad," he explained. "Now it is only ten. But the road leads over a mountain, and is full of chuck holes. In the spring time, when our heavy traffic must be carried on, the wheels sink axle-deep in the holes. If only we had an outlet to market." In 1904 the total expenditures upon the highways in a number of rugged mountain counties amounted to about $24 per mile. The average expenditure for the state, much less rugged and therefore requiring relatively smaller expenditures, was, nevertheless, $43.57. The history of the mountain roads emphasizes the inability of the people to provide themselves with efficient highways, and manifests the great need for outside help, state or federal. In general, road material would have to be imported at great expense. The costs of roads steadily increase as the forest retreats towards the headwaters.

In 1907 the United States Department of Public Roads as an object lesson built and macadamized in Johnson County, 5,780 feet of road and constructed through Cumberland Gap, 12,300 feet of macadam pike, and graded 900 feet more, at a total cost of $7,050 per mile. This work demonstrates again that the construction of good highways in the mountain region, while possible, cannot be done without outside help. Besides the government routes there is a short stretch of macadam road (one to twenty miles) in five marginal counties, of which, however, Boyd County alone lies strictly within the mountain region. The coal company at Jenkins has surveyed and built six miles of well-graded dirt road connecting Jenkins and McRoberts. Owing to the enforcement of the road laws in Knott County, a fairly good ungraded dirt road extends thirty miles between Hazard and Hindman. Immediately west of Pine Mountain in Leslie County, no wagon roads were attempted till 1890, and few exist now.

Before the advent of railroads, highway improvements were negligible, but the past twenty years have seen progress. Numerous stretches of road, eight to ten miles in length, afford somewhat fair transportation for wagons to the railroads. Where the development of coal and timber has increased the wealth of the community greatly, substantial bridges have been built. Progress has been slowest in the rugged, extreme southeastern section of the region, even though railroads have begun to penetrate. There the old-fashioned English saddle and the sleds drawn by oxen are still in use.

Except for lumbering, the streams are used but little. The North.

Middle and South forks of the Kentucky River penetrate into the interior. They join at Three Forks, near Beattyville. Thence to Carrolton are 350 miles of good waterway. In 1853 some five locks were completed by Kentucky at a cost of $4,000,000, which assured good navigation for 300-ton steamers for a distance of over 100 miles. The federal government made improvements at the close of the Civil War. Since then the waterways have been declining. In 1887 there were passing Three Forks annually, 50,000,000 feet of lumber, in logs.

Railroad building began in 1856, but made no headway until between 1870–90. The progress has been slow and confined to marginal counties until recently. Within the past five years a line has penetrated the North Fork Kentucky River to McRoberts, a few miles west of Pine Mountain, and up the Poor Fork of the Cumberland River, by way of the gap at Pineville. The railroads have been built for the coal and lumber, and not primarily for general traffic. Since the advent of railroads, the conditions which have made possible "the mountaineer" have been passing away.

But in general the region is still landlocked. And the brutal truth is that as long as it remains landlocked but little improvement on a large or permanent scale can be expected.

Population

It is in order now to summarize the changing conditions among the people of the mountains. In 1910 the total mountain population was 561,881, representing an increase of 18 per cent. over that of 1900 (Kentucky: 2,289,905; 6.6 per cent.). Figs. 9 and 10 show the growth in population in Kentucky and the mountains since 1860. There was an average of 43.4 people per square mile in 1910 (Kentucky, 56.9; Indiana, 74.9). The density is greatest along the main river routes and in mining sections. The people continue to be distributed as clans in valleys, which are surprisingly heavily populated. Of necessity the people depend upon the lower slopes of the hills as much as upon the limited bottom lands, their "shoe-string farms" being found strung along little gullies as well as in broader valleys. A few farms are on the mountain sides, especially on benches or "coves" of somewhat gently sloping land, formed above some massive sandstone ledge. The average size of the mountain family is about 5.2 (Kentucky, 4.6; Indiana, 4.1). The rural population increased 17.1 per cent. in the last decade (Kentucky, 4.2 per cent.). There was no urban population (people living in towns of 2,500 or more) in 1870. In succeeding decades, as Ashland and Middlesboro developed as centers of coal mining, it numbered 3,280; 7,466; 17,428; and 24,004. These two cities are unique in the region in having a population greater than 5,000; but they soon will be joined by Jenkins and Hazard, about which coal mining is developing rapidly. In 1910 less than one half of one per cent. of the

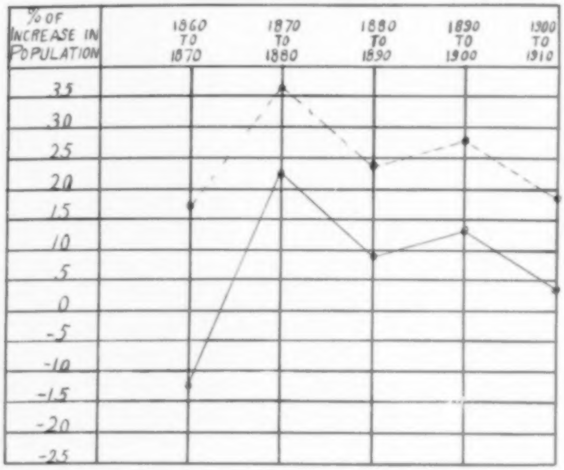


FIG. 9. GRAPH SHOWING THE PER CENT. OF INCREASE IN POPULATION IN THE MOUNTAIN REGION (BROKEN LINE) AND IN THE REST OF THE STATE (FULL LINE).

total population was foreign born. These people were chiefly skilled miners from England, Sweden, Germany and Switzerland, who drifted in by way of Pennsylvania. In seven counties there were no farmers of foreign birth; and in only one county did the foreign born exceed 21. Recently, Southern Europeans have begun to come, particularly Italians

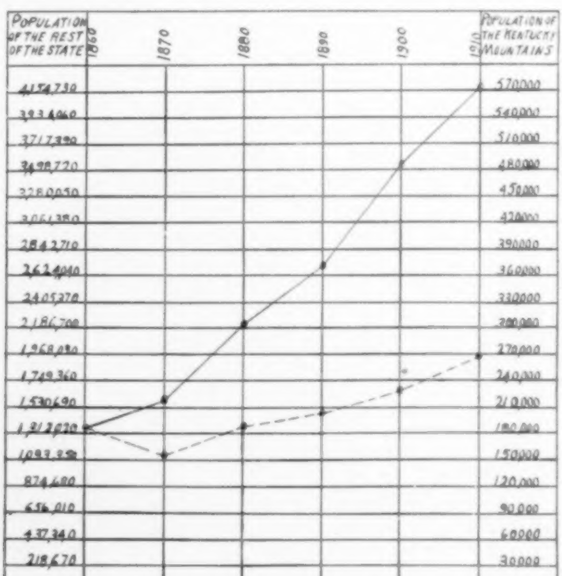


FIG. 10. GRAPH SHOWING THAT THE INCREASE IN POPULATION OF THE REST OF THE STATE (BROKEN LINE) SINCE 1860 HAS NOT KEPT PACE WITH THAT OF THE MOUNTAIN REGION (FULL LINE). **Had it done so the population of Kentucky in 1910 would have been over four and one half millions.**

FIG. 11. THE GENTLE SLOPE, DUE TO AN OUTCROP OF SHALE, HAS MADE IT POSSIBLE FOR THIS MOUNTAIN HOME TO BE RELATIVELY PROSPEROUS. Near Hindman.

and Hungarians. By 1920 the number of foreign born will have increased greatly. In 1900 about two per cent. of the population were negro, and in 1910 two and one half per cent. In three counties there were no negroes; and in sixteen, less than 20.

The problem presented in the region by the rapid increase in population with no corresponding increase in foodstuffs probably is not greatly overdrawn in the following statements by a mountain graduate of Berea College:

> The pioneer of 1850 who sat in his front door watching the deer rove the unbroken forest, to-day sitting in the same place can see acres of spoiled farm land. A few years ago the people produced enough on their farms to support themselves. To-day one half of the food consumed is brought in by the merchants. Twenty-five years ago our hillsides produced forty bushels of corn per acre. To-day the average yield of corn per acre is a little less than twenty-five bushels. (In 1909 it was 18.7 in the region.) The independent farmer of yesterday has been transformed in the last few years to a man dependent upon his staves and ties for support. Now, his farm is grown up in bushes, and his timber supply is almost exhausted. . . . Such is the condition of a vast number of our mountain farmers.

There is an emigration of the mountain families, or of sons and daughters, particularly from the marginal counties, where a fringe of mountain territory has been put in touch with outside progress and humanity, and where mountain peoples are buying adjacent lowlands. Some are moving to Oklahoma and the far west. This in part accounts for a decrease in the population of five counties. Not all of the emigrants become Lincolns (he was of their stock), though the mountain mind, not having been subjected to the specializations of our age, tends to remain fluid. Indeed many leaders in the mountains, including Mr. J. C. Campbell, secretary of the Southern Appalachian division of the

Russell Sage Foundation, have informed me that the great majority of these emigrants who go untrained into the economic struggle of the outside world fare poorly. I was strikingly reminded of this fact in a mountain pass by my guide, who said that one of his cousins has gone to Arkansas and has written for him to come also. My man informed me that he is "athinking about it in his mind." Sometimes he thinks he will go. "Does that land produce there?" he queried again and again. "Would it feed a man? What is the lay of the land? How high are the mountains, and the color of the soil, is it red? Some tells me as how it is a clay soil. But clay soil won't produce well. Hereabouts hit won't produce much more'n grass." I couldn't make him realize that far away Arkansas is a large state with varied soils and topography. I felt hopelessly that when I spoke of the tracts of level land in the country of promise, he thought of it in terms of the few acres of bottom land of his home hemmed in by mountains, for "isn't it true that that's what the world is, mountain and slope? Some tells me to go; some tells me not. I might go and find that the land wouldn't produce. I'm afraid that if I go, my kin 'll be het up about hit. Then if the soil won't produce, I'd have to come back, an' them set agin me."

Public health is not as good as might be expected at first thought. The situation has been summarized by Miss Verhoeff (in "The Kentucky Mountains") as follows:

> Endurance and muscular strength are common, but a strong constitution is exceptional. Bad housing and sanitation, ill-cooked and insufficient food, exposure to weather, and . . . poverty, have had their detrimental effects, which have been augmented by a close intermarriage of families and by an inordinately large use of liquor.

Fig. 12. Apples from an Abandoned Mountain Farm. Poor transportation makes their marketing impossible.

In general the mountain man is quicker than the Indiana plainsman, but not as strong. A month's field work did not bring to my notice any of the storied giants of the hills, though there probably are some. Not all of the people are lank.

About two generations ago trachoma penetrated into the mountains, and is spreading rapidly, despite the efforts of the state and settlement schools, and the federal government. Of over 4,000 people examined in five counties, 12.5 per cent. had this disease. A report from the W. C. T. U. Settlement School at Hindman, by Miss Lucy Furman, author of "Mothering on Perilous," names twenty-five per cent. for that locality. Adenoid and turbinate cases are common. President Murdock says that several clinics held at his Presbyterian college at Buckhorn revealed that ninety per cent. of those examined were afflicted with hookworm. Splendid work is being done, but the area to be covered is a vast one, and assistance is needed greatly. Superstitions that diseases are visitations of the Lord to be borne with resignation are disappearing slowly.

The people continue to be poor. In 1900 land was worth $5.00 per acre, and 1910, $9.66 (Kentucky, $13.24 and $21.83; Indiana, $31.76 and $62.36). The average value of all farm property per farm in 1900 was $860; and in 1910 it was $1,359 (Kentucky, $2,007 and $2,986; Indiana, $4,410 and $8,396). The average value of farm buildings per farm in 1910 was $247 (Indiana, $1,230).

Institutions

There is great need of education. In 1900, 24.3 per cent. of the voters were illiterate, and a decade later, 20.7 per cent. (Kentucky, 15.3 and 13; Indiana, 5.6 and 4.1). In eight counties, in 1900, the illiterate voters constituted from 30.5 per cent. to 35.8 per cent. of the total. In 1910, 61.6 per cent. of the children, ages six years to twenty, were in school (Kentucky, 60.8; Indiana, 66). Corresponding figures for children from six years to fourteen years were 73 (Kentucky, 76).

However, improvement is being made. In 1900, there were more than 20 counties without a local publication. Now, there are but few counties without a press, and several have more than one.

Formerly, the term of school lasted but three months in the year. The teachers received no training except in the common schools. The buildings were tiny, two or three teachers in some cases teaching in the same room. But now, the term lasts six months (closing at Christmas owing to bad roads). Also, many of the teachers receive some training in the normal department of the settlement and missionary schools. Furthermore, there is but one teacher in each room, though in it are no library, few modern desks, and little equipment. In one mountain school visited by the writer in 1914, the pupils were sitting in rough board pews, the boys on one side of the room and the girls on the other.

The walls, floors and seats were dirty. Two of the children were suffering from trachoma. The equipment owned by the school consisted of one wall map and three calendars. The only object on the desk was a small switch. The girl-teacher, who was a graduate of the institute at Oneida, had charge of 69 pupils and, besides, was teaching, without pay, a "moonlight" school of evenings, to which people of all ages were coming. She did not show any surprise or nervousness when our group of ten men in nailed boots filed in. Nor did the children pay much attention to the visitors. The third grade droned out its reading lesson, and then the second grade carried out its solemn program in spelling. There was a solemnity about it all which the outsider does not understand until he becomes acquainted with the gravity of these people in their gatherings. Progress was being made, though it seemed a pity that the children should have to learn the definition of some words which probably they never will have occasion to use. The day of the "shouting school" (in which the pupils indicate that they are studying by reading aloud) has passed in the mountains. In a second school, a girl, younger than the first teacher, was in charge. She had had no training beyond the common school. There were a few modern desks, but also some rough hewn pews. When I tiptoed to the door and took a photograph of the interior she showed less surprise than an Indiana schoolmistress would have exhibited, but she smiled when some of her children awakened to the situation. In a third school a middle-aged man was in charge. He said that in some sections a holiday week is declared during the corn-harvesting season. We visited also the mission and W. C. T. U. settlement schools, which are coming into the country; as at Buckhorn, Hindman, Pine Mountain Postoffice, and Blackie. In these schools, conditions are much better. Many of the teachers are college graduates. I have in mind one of them, a young woman, who would be considered an excellent teacher in any of our universities. One of the teachers had just returned from a vacation in New England, and another, from Paris. It was a privilege to meet these people of genuine culture among the hills. Their helpful and unselfish presence among the mountaineers is a good omen. An unfortunate feature of these institutions is the extreme scarcity of men teachers.*

Berea College, on the western margin of the region, serves as a university for the mountains, and is sending its extension department with wagon and camp into the remote sections. The reader is referred to the December, 1912, number of *The American Magazine*, for the story of the heroic foundation of Oneida Baptist Institute, and is reminded of Bulletin Number 530 of the United States Bureau of Education, for the story of the opening of "moonlight" schools in the Kentucky mountains in 1911 for children, parents and grandparents. When the feud breaks out, mountain mothers from the section in which blood is shed,

FIG. 13. MANUFACTURING IN THE HEART OF THE HILLS, NEAR PINE MOUNTAIN POSTOFFICE.

anxious to get their sons out of danger, are wont to urge them to attend school at Berea College and elsewhere.

Though in some sections enthusiasm for education is becoming great, in others there is great apathy, because of lack of interest on the part of the people, lack of practical teaching, illiterate teachers, poverty, poor roads and political interference in school affairs. In some districts it is still thought by the school trustee that "the lickenest teacher makes the knowinest younguns." Changing conditions are indicated by an incident in which two teachers appeared in the same school room, each determined to become the sole teacher. The following among the pupils was about equally divided at first, but presently they moved away from the teacher using the "A, B, C" method and grouped themselves about the more progressive instructor who was following the sentence method. The broad effect is being made to teach the people how to work and live according to modern ideas, and yet to retain the desirable traits of their own civilization. This is a delicate task, involving much more than merely academic training.

Religion is undergoing transition slowly. Formerly if a speaker did not shout and gesticulate he might be termed a good *speaker* but not a good *preacher*. The early attitude towards the settlement workers was indicated in a mountain sermon in which the congregation was told to "beware of the fetched on women who come in here wearing gold watches, and their shirt fronts starched so slick that a fly would slip off and bust out his brains." But, a year later, the mountaineer said that since these women were administering to the needy under conditions so harsh that even the mountain people would not venture out, "I allow as how they are welcome to stay in the mountains as long as I live." One mountain patriarch, who has given his farm and essentially his all in

founding a settlement school in the valley of his home, gave some of his reasons for doing so essentially as follows: That there was much whiskey and wickedness in the community where his grandchildren must be reared "was a serious thing for him to study about." Also, he heard two of his neighbors say that there is neither heaven nor hell. Furthermore, one of them told him that when a man is dead he is just the same as a dumb beast. And another said that he could not rear his large family of children to be as mean as he wished. With these conditions in mind the founder hoped that by starting a good school he "would help moralize the country." Formerly the Presbyterian religion was most prevalent, but it gave way to the "Hard-shell" Baptist creed, since in the mountains the educational qualifications for the latter were less severe than for the former. The disciples of this religion have in turn given way before the "Missionary Baptists." Methodists are also numerous. The most vivid disputes in the mountains were wont to be about religion. But now there is a significant change toward toleration in that preachers frequently exchange pulpits with pastors of other denominations, and that the use of a church is often tendered to another denomination which temporarily is without a place of worship. The following can be interpreted as a groan of growth. "The church in eour holler, hits about dade. Part ov the folks want an eddicated preacher, and parts wants an old timer, an so they don't get nary one." The funeral preaching had become the sole opportunity for social gathering until the recent advent of "camp meeting week," and the coming of the extension school on wheels.

Changing conditions have not yet affected greatly the political situation in the mountains. Since the Civil War so many of the inhabitants have been Republicans that party arguments have been one-sided, and the contests have been within the organization. Unity of feeling in the

FIG. 14. THE ROAD FROM LINE FORK TO THE HEADWATERS OF GREASY CREEK. This is one trade route of the 500 people living near that creek.

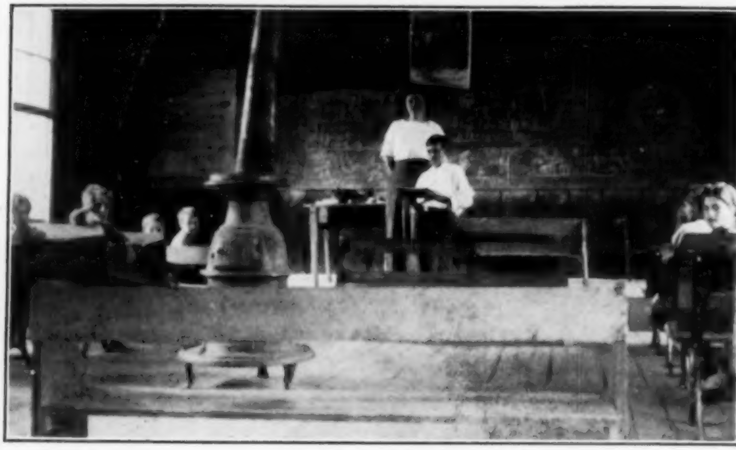


FIG. 15. A MOUNTAIN SCHOOL. The girl-teacher also "holds" "moonlight school" in this building.

mountains gives the representatives considerable power in the State Legislature. Political discussions are said to be confined in general to stump speeches concerned with national issues, and hence are of little help concerning local problems. However, since the mountain men are good at politics, some make a profitable business of the local contests. Recently in some sections some are said to have turned their attention to the school, for the sake of profit in the appointment of teachers. There the trustee runs for office upon a platform-statement of which teachers he favors. In some sections the vote runs high in school elections, while it is light on other matters. An increasing number of women vote on school affairs. Another favorite field of the politician is the handling of road taxes.

Deep-seated prejudice, due to poverty, exists against taxation of any kind. In 1906 the per capita state-and-county tax was $4.62 for Woodward County, in the Blue Grass, while in the mountains it ranged from $.40 in Elliott County to $1.75 in Harlan. Little returns are obtained by taxation of lumber and mineral resources.

The feud was transplanted from Europe into the Blue Grass, the Kentucky Mountains, and elsewhere. It survived among the isolated valley of the mountains, where it was fostered by folk-song, the flaring resentment of the Indian fighter and pioneer, and the habits of thought natural in isolated communities where for a long time there was neither sheriff nor jury, and where, even to this day, the government hardly has been able to inspire confidence or dread. The Civil War greatly increased and intensified the feud: Prior to 1860, few weapons had been used in the mountains, and few deaths had resulted. In the region in 1860 there were 10,098 slaves and 1,280 free colored people. The lines grew sharp between the Union and Confederate counties, as well as

between opposing families, and between opposing members of a family. Modern arms were introduced into the region. The physiography of the land favored bushwacking. During the war the Kentucky mountaineers suffered more sharply than the mountain people of any other state, except Tennessee. Also, many of the principals of the post-war feuds were boys during the Civil War, whose imaginations were filled with the horrors which the mountains witnessed during the four years. It is said by the mountain people that the actual numbers engaged in the feuds has ranged from 10 to 60 on a side; that the duration has been from 1 to 40 years; that perhaps not 10 per cent. of the mountain people have had a personal difficulty sufficient to cause fighting; probably not 40 per cent. of them have gone to a court house to prosecute or defend a case; and that half of the enlisted partisans never have faced the music on a showdown fight.

In some parts of the region, as about Oneida, education is causing the decline of the feud; but in other sections it flourishes, as near Pound Gap ("Trail of the Lonesome Pine"), near where, it is said, some eleven men were killed in three months during the spring of 1914.

The home, also, is changing. One still can see the windowless log cabin with its "dog-trot"—the open passage way between the two rooms; but some roofs are of shingles, and some of tin, while frame structures are appearing, and brick. Mountain simplicity and hospitality are illustrated by one man who said, "I want a good house; two rooms . . . one for the family and one for company, each big enough for a bed in every corner . . . and a lean-to cook room."

The following is a description from Professor Penniman's unpublished tales of the mountains:

Three days are ample to build a log-cabin twenty feet square. The part before the roof is called a "pole pen." This is run up in a few hours. The

FIG. 16. THE PRESBYTERIAN MISSION SCHOOL AT BUCKHORN.

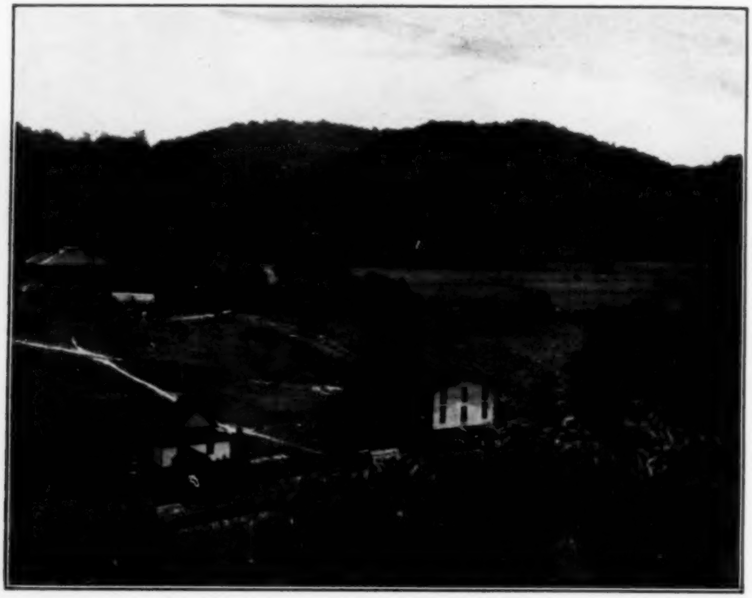


FIG. 17. THE ONEIDA BAPTIST INSTITUTE, founded by John Burns, of the moun-

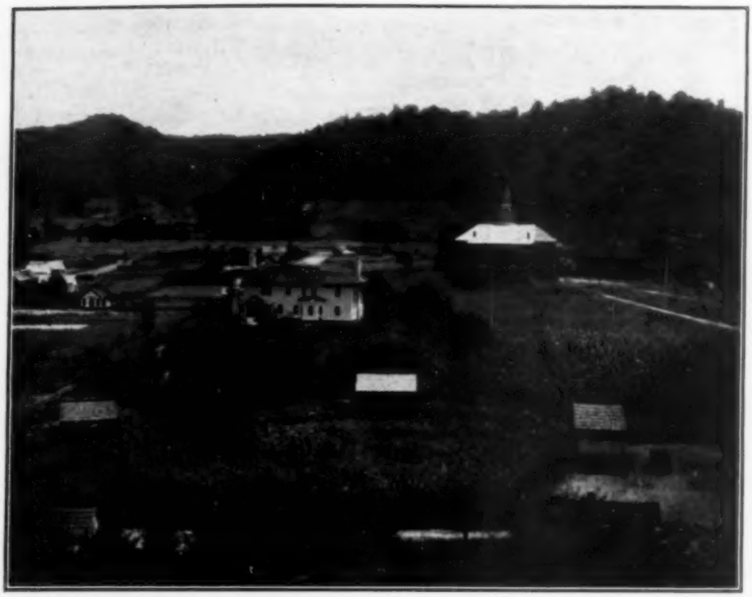
trees sufficient to build a cabin complete are often standing on an acre. With the roof up, and stone chimney on the outside, and the big fireplace opening into the room, the young people can begin housekeeping. A few saplings will make a bed frame fastened to the logs in one corner, and a bed without a tick, two feet thick, of fresh pine needles, gives a sense of luxury to the newly married pair.

Customs and Habits

It must be remembered that there are all grades of society in the mountains, and that no general description can be applied to a specific case.

Woman is inferior to man in both number and position. In 1910 the males numbered 289,315, and the females, 272,566. Not only is she a household drudge, but a field hand as well. (Out-of-door work in itself, of course, does not constitute drudgery.) She still follows behind him as they trudge over the mountain. A mountain boy, upon being asked how many brothers he had, answered me promptly: "Two." But concerning the number of sisters, he drawled: "Oh, three or four." The modern Woman Movement hardly has penetrated into the hills, and, when it does, it will meet orthodox opposition. However, women increasingly vote in school affairs in some districts. Furthermore, here and there, a girl returns from Berea, or some other college, with ideas strange to her people. Perhaps this explains the wide girdle, or other bit of modern adornment, now seen sometimes on the quaint costumes.

We were pushing through a deep forest in climbing over a ridge.



tains. This was the scene of the Baker-Howard feud. (Photo by H. Hesse.)

Before us were two children, walking in single file, a boy of fourteen and a girl a year younger. Our youthful guide pointed in their direction and remarked; "They were married last spring. Some of us do get married that early hereabouts; but we who have been to the settlement school don't calculate to get married that soon."

"Store clothes" have displaced homespun garments, the result being unfavorable in the appearance of the men. However, the settlement schools are reviving the home-weaving industry to some extent. The belt is beginning to rival the suspender on "Sunday" garments.

The quaint Old English language also is disappearing, though slowly. It is becoming crystallized and is losing its flexibility whereby it was wont to be bent this way or that, to suit the fancy or fit the occasion. In a reminiscence of his boyhood, Professor Dizney tells of a minister in Dizney's valley, who, in preaching about apostasy, took as his text: "If they shall fall away," and who concluded in a high key:

"If they shall fall away," means that they can not fall away, for anybody who knows anything about the English language knows that it is a verb *in the impossible mood and everlasting tense!*

There also comes to mind the following expression: "Law me, Honey, I'm glad to be back from the plains. Wooded mountains make the restinest place to lay your eyes on."

There is about to pass away a most interesting folksong based upon English and Scotch ballads, and preserved verbally in the mountains with slight modification, from generation to generation. These songs

of romantic love, hate, sacrifice and revenge are sung in almost all of the log cabins. Thereby the visitor, who may have thought that the mountaineers neither weep nor smile, learns with delight that their natures are intensely fluid. The songs are sung in slow time, and in minor tones difficult to express in written music. An effort is being made to collect the words and write the music before it becomes too late.

The open hospitality, once common, is shrinking. An old man in his watermelon patch put it thus: "I used to raise melons for the whole valley, so that the folks would come to sit and talk with me on the porch while we ate them. But now too many foreigners have come in; they would eat me out of home." There is a kindly affectionate courtesy for one another among the people, which, it is hoped, will survive.

There is such a great need for improvement in sanitation that what has taken place is negligible.

The native is accustomed to work in his fields by seasons, with periods of rest between. In fifteen days of travel I saw, during one of these "off" periods in September, but two men at work in the field. It has been his wont to work during the favorable time, or when the larder is empty; or to rest during the unfavorable season, or while provisions are at hand. Therefore, in general, the population is unsuited to the routine of work in the mines, the manufacturing plants, and the lumbering camps, now appearing in the region under the control of outside capital. Furthermore, it is without a disposition to cooperate. Hence such workers are at once the despair and menace of the employer and the labor union. Consequently, foreign labor is imported, and the mountain man is in the way, as was the Indian. He will not necessarily become happy if, to meet modern industrial conditions, he throws off lightly his old attitude toward life gained through centuries of adaptation in the mountains. A few of the most versatile natives are profiting by the rapid changes; but the great majority, formerly independent land-owning farmers, are not. Many are seeking employment in mill or mine, or are withdrawing to the headwaters. It is significant that the leaders in the mountains, native and mission, deplore the *rapid* advance of industry into the region, and that they are bending every effort to prepare a civilization over a century in arrears, to meet the rude shock of the worst of our culture. In the 1911 term of court, Perry County, being invaded rapidly by railway construction, had nearly 600 cases: Owsley County, without access to railways, had less than 40 cases. A mountain guide in Pound Gap lamented, "The devil is coming into the mountains on wheels." Eight years ago I rejoiced with a clean cut, delightful, energetic man who was returning home from the Kentucky Mountains buoyant because he had doubled his fortune by securing some of the virgin forest at an absurdly low price. He was bringing wealth and good cheer to his northern family. Now, with those slopes in mind, deforested, gullied, scorched, and sold ("unloaded"), I am not rejoic-

ing. Most of the mineral rights have been bought by outside capital, much for $1.50 per acre, and in some cases for $.50. Sometimes the mountain people made the further mistake of giving up the farming rights also. At Jenkins the wives were paying high prices at the company stores. Twenty miles from one of the new mining towns, a mountain girl, grown coarse by contact with the frontier of civilization, boarded our train and by her lewdness shocked, among others, two refined young women of the hills to such an extent that one of them said: "I am ashamed that I am a woman," and was answered by her comrade: "I'll hush forever on the train." The *rapid exploitation* of the natural resources of a region by outside capital tends to harm the native, especially if his civilization is not modern. In this case the outcome is in the balance.

The Future

If exploitation pure and simple continues, twenty-five years will bid fair to bring about the following results: The disappearance of this race of true Americans as a unit; the passing of the valuable timber; numerous forest fires in the region slashed over; greatly increased erosion of the steep hillsides with their soil already thin; short periods of flood within and below the region; long intervals of low water within and below the region; the reduction of fish and game; the introduction of a foreign mining element, also a foreign manufacturing body; and a district of great natural beauty changed to a region of squalidness. Presently, with the increase of population and the value of land in the United States, the wastes may be reclaimed at great cost.

Outside aid might do the following things: Regulate the exploitation of the coal and timber so that it will be gradual; aid the counties in building good roads; assist in educating the mountain people along broad lines to close the gap between them and us; help them to develop stock-raising, fruit-growing, scientific agriculture and scientific forestry. Some of the results would be: The saving of the mountain race as a unit; the addition of a happy, prosperous, food-supplying area to the United States; the prevention of the disasters of soil erosion and of flood; and the utilization of water power.

There is one thing more which might be done. It is being pointed out that men break down under the tension of modern industrialism, unless they, somewhow, are brought into contact with the beautiful, and get away for frequent moments of change and recreation. The government owns our national parks; but they are far out west, beyond the financial reach of the average worker. The government might also establish numerous small parks in the Southern Appalachian Highlands, which would become the recreation ground of millions of workers east of the Mississippi River.

Ronald Ross

RONALD ROSS AND THE PREVENTION OF MALARIAL FEVER

By MAJOR GENERAL WILLIAM C. GORGAS

SURGEON GENERAL, U. S. ARMY

AND

FIELDING H. GARRISON, M.D.

WASHINGTON, D. C.

ON Wednesday, December 10, 1902, at Stockholm, the Nobel prize for medicine, the second to be awarded, was bestowed upon Sir Ronald Ross for his demonstration of the transmission of malarial fever by mosquitoes. His immediate predecessor in the medical award was von Behring (1901), his successors were Finsen (1903), Pavloff (1904), Koch (1905), Golgi and Ramon y Cajal (1906), Laveran (1907), Metchnikoff and Ehrlich (1908), Kocher (1909), Kossel (1910), Gullstrand (1911), Carrel (1912), Charles Richet (1913), and Robert Bárány (1914). In this distinguished company it is noticeable that no less than three of the prizemen—Ross, Golgi, Laveran—were honored for their scientific work on the causation of malarial fever. To understand the significance of Ronald Ross's career, let us briefly consider the history of this disease.

Malarial fever has been known from the earliest times. It is well described in the medical writings of the ancient Greeks and Hindus. The intermittent forms, commonly known as quotidian, tertian and quartan, had already been differentiated by Hippocrates, who noted the principal symptoms, established a connection between the characteristic malarial enlargement of the spleen and marshy stagnant pools of water, and attributed the disease to the drinking of such water. Before the fifth century B.C., Greece was a mosquito-ridden country, but free from malaria. The disease was probably introduced by immigrants, as happened at Mauritius in 1866. After the age of Pericles, references to it became more extensive in literature, and the resulting rural depopulation had much to do with the downfall of Greece. The physicians of modern Greece have found the swamp fevers of their country to be not different from those described by Hippocrates in Thessaly and Thrace. One of them, Cardamatis, holds that some of the labors of Hercules symbolize the reclaiming of marshy areas from malarial fever, which he thinks identical with the "epiala" of the poets Theognis and Homer. The philosopher Empedocles (fifth century B.C.) was actually deified by the townsmen of Selinus for freeing the Sicilian city from malarial fever by draining the swamps in its vicinity. The Romans had a special goddess of fever (Mephitis), a bald, emaciated, dropsical figure who had a temple

on the Capitol, and whose very name suggests the swamps and their exhalations. The summer and autumn dangers of the Campagna were well known to the Roman satirists, Horace and Juvenal, who also mention the mosquito-net (*conopeum*). The close attention which the Roman architects paid to the construction of splendid aqueducts and drains shows their intuitive feeling about these things. A number of Roman writers on agriculture and architecture attributed malarial diseases to swamps, to the emanations from them, and to the small living creatures found in them. As these citations, first given by Lancisi, are always quoted in the original Latin, it may be well to translate them.

Varro (116–27 B.C.), writing on husbandry, says:

> It should be noticed whether any localities are marshy, for the same reasons, and because, when they dry up, certain minute animals are engendered, which the eyes can not see and which get into the body through the air by way of the mouth and nose, causing troublesome diseases.

Vitruvius, the architect (first century B.C.), says:

> The vicinity of a marsh is to be avoided, because, when the morning airs reach the house at sunrise, the mists of these places arrive with them, and the wind, mixed with these vapors, spreads the poisonous exhalations of the creatures inhabiting the marsh, and so makes the place pestilential.

Columella, the agriculturist (first century A.D.), says:

> Nor should buildings be erected near a marsh nor a military road adjoin it, because through heat it gives forth noxious poisons and engenders animals armed with dangerous stings, which fly at us in dense swarms.

Palladius says, in his poem on agriculture (fourth century A.D.):

> A marsh is by all means to be avoided, especially one lying to the east or west, and usually drying up in summer, because it engenders pestilence and harmful animals.

These extracts show that from the second century B.C. to the fourth century A.D. and after, the Romans had a clear notion of the relation between the fauna of marshes and malarial fever. The Hindus went even further. In the Susruta, a Sanskrit medical treatise which is at least 1,400 years old, the symptoms of malarial fever are clearly described and attributed to the bites of certain insects. Hints as to the connection between marshes and malarial fever will be found scattered through secular literature everywhere, for instance, in the dismal illustrations of the first edition of Mrs. Trollope's "Domestic Manners of the Americans," representing the ague-ridden inhabitants of the banks of the Mississippi, or in such a tale of the marshes as Baring-Gould's "Mehalah." Dr. Holmes, in "The Autocrat," likened the intermittent forms of malarial fever to certain short-lived insects—in that they "skip a day or two."

In 1618, the Countess Chinchon, wife of the viceroy of Peru, was healed of an intermittent fever by the use of cinchona bark, which was

introduced into Spain by her physician, Juan del Vigo, in 1640. The fact that cinchona, being a specific, not only cures malarial fever, but also differentiates it from other infections, gave a peculiar impetus to the study of the disease, which was carefully followed in England by Sydenham and Morton, in the seventeenth century, by Lind and Pringle, in the eighteenth century, and in Italy, by two great physicians, Lancisi and Torti. Lancisi, in 1717, published a large treatise on the noxious airs of swamps,[1] in which he revives views of the earlier Roman writers about the insects arising from them, in particular, the mosquitoes (*Culices*), of which he gives a naturalist's account, even suggesting their possible agency in inoculating disease. While he still held, in part, to the ancient doctrine of miasms or effluvia taken into the body *via* the respiratory and alimentary tracts, he was prone to regard these effluvia as organized or organic. The following luminous sentences, which have not been translated before, reveal the quality of his vision:

Cap. XVII., III. (p. 61): In a previous chapter, I have shown that mosquitoes (*Culices*) and other insects make their nests on the water during summer. It can therefore be easily seen that near swamps, where there are so many kinds of organisms and whence their multitudes are thrown into the surrounding air, the water, which the inhabitants use for drinking, is infected with these organisms.

Cap. XVIII., IX. (p. 66): Furthermore, no controversy can surely arise among professional men concerning the harmful effect which the insects of the swamps inflict upon us by mixing their noxious juices with their saliva and gastro-intestinal fluids. For, as I have shown above at length, their proboscis is always wet, and, as all their viscera are full of deleterious liquids, it is not possible that the juices rolling down with food and liquids into the stomach, are not there mixed with our ferments. . . . For this reason, we may conclude that marshy insects are highly injurious to the body of man by the inmixture of deadly juices as well as by the withdrawal of the useful ones which are in us.

Cap. XIX., III. (p. 72): Moreover, I take the rôle of a seer and not of a philosopher if I, without experiments, venture to affirm that, in camp fevers of this sort, the worms penetrate and ascend the blood vessels. For it would be necessary that the blood of those suffering from marsh fevers should be let, which medical reason seldom admits; and to carefully examine the blood with a microscope for insects of this kind, if such there be. But, although worms might be seen in the drawn blood, it would still be doubtful that these insects should be considered as the cause of the evil; or whether, which I consider more probable, it is the product of the breaking down of the fluids; whence all the minute ovules, after they have been wrapped up in particles of the blood, are set free or are supplied from the external air. I can therefore form no opinion from autopsies whether these diseases are carried by insects into the blood. Being rather content with a confession of my own ignorance, I must frankly concede that neither in abscesses due to nature or produced artificially in patients who frequently come from the neighboring swamps to Rome, nor in the examination of dead bodies, have I found insects in other viscera than the stomach and intestines, where they found room, quietude and food more easily than

[1] G. M. Lancisi, "De noxiis paludum effluviis eorumque remediis," Rome, 1717.

elsewhere. For the rest, through the supreme goodness of God, I have never been called upon to treat the plague, and, for this reason, I gladly refrain from expressing a definite opinion concerning pestiferous worms in the blood, as being a thing I know almost notning about.

Lancisi also shows that good drainage drives away fevers. The great aqueducts and drains of the ancient Romans had apparently been designed for this purpose, and, through the Middle Ages up to the nineteenth century, the Papacy made many efforts to drain the Pontine Marshes and to cultivate the deserted Campagna, methods of sanitation which Ross summarizes as the "principle of mosquito reduction." Torti, at Modena, introduced cinchona bark into Italian practise, and by its use differentiated the pernicious forms, which do not yield to treatment, and of which he gave the classical account (1712). He also introduced the term "malaria," from the Italian *mal'aria* (bad air). The expressive term, first employed in English by John Macculloch, in his treatise "Malaria" (1827), epitomizes the earlier theory of its causation, viz., that it is due to miasms or effluvia, *i. e.,* gaseous emanations given off by stagnant water or even by the earth itself.

The next step in the history of malarial fever was the discovery of the parasites causing the disease. The theory that diseases may be caused by minute living organisms, invisible to the naked eye, is also very old, as is plain from the above citation from Varro. It was first stated in scientific form by Fracastorius, in his treatise on contagion (1546), and later by Athanasius Kircher (1658), who investigated minute organisms with the microscope. In 1730, as cited by Professor W. S. Thayer, Thomas Fuller, an English physician of the eighteenth century, made the following quaint suggestion that malarial fever may be caused by minute organisms:

Can any Man, can all the Men in the World, tho' assisted by Anatomy, Chymistry, and the best Glasses, pretend positively and certainly to tell us, what particles, how sized, figured, situated, mixed, moved, and how many of them are requisite to produce a quartan ague, and how they specifically differ from those of a tertian?

Agostino Bassi, who discovered the microorganisms causing silkworm disease, relates that the physician Rasori of Milan said to him of his discovery:

I am fully persuaded of the truth of your useful discovery. For many years I have held the opinion that the intermittent fevers are produced by parasites which call forth a new paroxysm by the act of their reproduction, which occurs at more or less rapid intervals according to the diverse species. In this way, the intermittent fevers, quotidian, tertian, quartan, arise (1846).

In the meantime, Jacob Henle had published his essay "On Miasms and Contagia" (1840), stating his theory of living contagia, with reference to Bassi's work; and, in 1849, Dr. John K. Mitchell published his treatise "On the Cryptogamous Origin of Malarious and Epidemic

Fevers," in which these diseases are attributed to minute fungi. This essay is a landmark in the history of the doctrine of contagion, but, for our purpose, the most important sentences in it are the following, referring to the causation of malarial fevers:

> Whatever may be their cause, it seems to have activity almost solely at night. *Darkness* appears to be essential to either its existence or its power.

Yet, strange to say, Mitchell, carried away by his theory of a fungous cause, says nothing whatever about mosquitoes, which were coming to be recognized more and more as agents in the production of both malarial and yellow fevers. In an old ordinance of Freetown, Sierra Leone, dated 1812, and cited by Kennan, the inhabitants (mostly freed slaves) are enjoined to keep the road in front of their plots in good condition in order to prevent the formation of "stagnant pools which generate disease and mosquitoes over the town" (Ross). In 1848, Dr. Josiah C. Nott, of Mobile, Alabama, advanced the provisional theory that yellow fever and malarial fever are of "probable insect or animalcular origin." It is sometimes asserted that Nott regarded the mosquito causation of malarial fever as proven. The only statement in his brilliant but rambling essay which suggests anything of the kind is the title of the paper itself, viz., "Yellow Fever contrasted with Bilious Fever—Reasons for believing it a disease sui generis. Its mode of Propagation—Remote Cause—Probable insect or animalcular origin, etc."[2]

The explanation of Nott's statement is simple. He got his theory of malaria, as every one else did, from Lancisi. In 1854, Louis Daniel Beauperthuy, a French physician residing in Venezuela, assigned a definite species of mosquito as the cause of yellow fever, holding that the poison is injected under the skin by the insect, as in snake bite. In 1866, Salisbury attributed the causation of malarial fever to spores of the vegetable family Palmella, and in 1879, Edwin Klebs and Tommasi-Crudeli announced the discovery of a *Bacillus malariæ*, neither of which availed as the true cause. The next few years witnessed a sudden leap in knowledge. On November 6, 1880, Alphonse Laveran, a French army surgeon, working at Constantine, Algeria, discovered the parasite of malarial fever, and in 1881, described three of its forms. In 1881 also, Dr. Carlos J. Finlay, after making a series of careful bionomic observations and some inoculation experiments, announced that yellow fever is transmitted *from man to man* by a special species of mosquito (*Stegomyia*[3] *calopus*), a theory which was to be proven in the most rigorous way by Major Walter Reed, of the U. S. Army Commission, and

[2] J. C. Nott, *New Orleans Med. and Surg. Jour.*, 1847–8, IV., 563–601. See on this point the essay of Dr. Juan Guiteras, "Insect-borne Diseases in Pan-America," Habana, 1915, p. 33.

[3] Finlay, *An. r. Acad. de cien. med. . . . de la Habana*, 1881–2, XVII., 147–169.

his associates, Carroll, Lazear and Agramonte, in 1900. Prior to Finlay however, Sir Patrick Manson had, in 1879, demonstrated that the mosquito transmits the disease produced by the parasite *Filaria*. In 1883, Dr. A. F. A. King, an English physician residing in Washington, D. C., gave nineteen cogent reasons why mosquitoes should transmit malarial fever and suggested screening the city from the marshy Potomac flats. In 1884, Carl Gerhardt demonstrated that malarial fever can be transmitted from the sick to the healthy by inoculation of the blood of the former,[4] in other words, as Ross says, "that the disease is not due to any gaseous emanation from the marshes, but is a true infection by some living virus." This laboratory demonstration of Gerhardt's may be said to have abolished the Miasm Theory of malarial fever. In 1885–6, Camillo Golgi,[5] at Pavia, showed that the Laveran parasites reproduce by formation of spores, and that the paroxysm of fever begins, as Rasori had surmised, just when the spores are liberated. That the parasites of the different forms of intermittent fever are different from each other and that similar parasites are found in birds was speedily shown by Marchiafava, Celli, Grassi and other Italian observers. In 1884, Laveran, and, about the same time, Koch, suggested that mosquitoes, as abounding in marshy places, may play the same part in malarial fever which Manson had shown them to play in filariasis. In 1894, Manson, in drawing a parallel between the malarial organism and *Filaria nocturna,* suggested that "the mosquito having been shown to be the agent by which the *Filaria* is removed from the human blood vessels, this, or a similar suctorial insect must be the agent which removes from the human blood vessels those forms of the malaria organism which are destined to continue the existence of this organism outside the body. It must, therefore, be in this or in a similar suctorial insect or insects that the first stages of the extra-corporeal life of a malarial organism are passed."[6] It is just at this point that the work of Ronald Ross looms large in importance.

Lieut.-Col. Sir Ronald Ross, K.C.B., F.R.S., the son of General Sir C. C. G. Ross, an eminent English soldier, was born on May 13, 1857, received his medical education at St. Bartholomew's Hospital, London, graduated in 1879, and entered the Indian Medical Service in 1881. He began to study malarial fevers in India in 1889. Doubting the truth of Laveran's discovery, he at first, after the fashion of Broussais, regarded the infection as the result of intestinal auto-intoxication. Being in London in 1894, he became acquainted with Manson's mosquito theory and upon returning to India the next year, undertook to verify

[4] C. Gerhardt, "Ueber Intermittensimpfungen," *Ztschr. f. klin. Med.*, Berl., 1883–4, VII., 372–377.

[5] C. Golgi, "Sull' infezione malarica," *Arch. per le sc. med.*, Torino, 1886, X., 109–135.

[6] Manson, *Brit. Med. Jour.*, Lond., 1894, II., 1306.

it by experimental demonstrations. In 1895, he received the triennial Parkes Memorial Prize of 75 guineas and a gold medal for the best essay on "Malarial Fevers: their Cause and Prevention," Manson and Sir Almworth Wright being among the judges of the eleven essays presented. This essay simply summed up what he had learned from Manson.

Lancisi and his successors held that the malarial parasite or poison may somehow be carried from the marshes to man by mosquitoes. Manson, applying the analogy of his theory of the transmission of filariasis by the mosquito, thought that the insect carries the parasite from man to the marshes, laying her eggs on the surface of the water and dying in the act of doing so. He inferred that the embryos of the malarial parasite infect man by the digestive tract through the drinking of contaminated water. But long before Manson had taken up this hypothesis, it had been completely disproved by the Italians, Marchiafava (1885), Marino (1890) and Zeri (1890), whose careful experiments showed that it is impossible to infect healthy persons by the ingestion of water from the marshes. When Laveran investigated the malarial parasite in 1880, he found that certain large cells in the withdrawn blood give off long motile filaments, like the tentacles of the squid, which were supposed by Grassi, Bignami and other Italians to be the effect of the death agony of the parasite *in vitro*. Manson inferred that these filaments are in reality flagellate spores which escape from the parent parasites taken from the patient's blood by the mosquito and develop into the matured forms afterwards found in other malarial blood. So far, his theory explained how the parasites escape from the blood of an infected patient into the external world *via* the mosquito. But the important question was, how do they get into the body of a healthy patient and infect him with malarial fever? Ross soon found, like the Italians before him, that the hypothesis of the infection of the alimentary tract by drinking water falls to the ground completely. The real point of attack was obviously the motile filaments. He began his work at the malaria-ridden post of Secunderabad in 1895. In prosecuting his researches, he had first to devise methods for collecting, classifying, feeding, breeding and dissecting the mosquitoes themselves. He soon found that his Indian insects fall into three general classes, the brindled mosquitoes (*Stegomyia*), the gray (*Culex*) and the dappled or spotted-winged (*Anopheles*). He caused mosquitoes hatched from larvæ of these varieties to bite malarial patients and tried to find the parasites in the bodies of these insects, which were obviously free from malarial or other extraneous parasites of any kind. For two years, with constant improvement of technique, he labored at this problem without much success, his work being interrupted by a year and a half's detail to fight a cholera epidemic at Bangalore and by the Afridi War. At Bangalore, he made some inoculation experiments with mosquitoes upon Mr. Appia, assistant surgeon of the Bowring Civil

Hospital, and others, but without success. His natural inference was that either the disease is not inoculated by mosquito bites or that he had not got hold of the right kind of mosquito for the purpose. In April, 1896, he was sent to Ootacamund, a great hill station in the Nilgiri Hills, 8,000 feet above the sea level, and here among the tea and coffee plantations at the foot of the malarial Sigur Ghat, a trench-like hollow in the hills, he made his first step in advance, for here he found and began to concentrate his attention upon the dapple-winged *Anopheles* mosquito, which was to prove the true vector of the disease. Ordered back to Secunderabad in July, 1897, he repeated all his experiments upon the gray and brindled mosquitoes, without success, but did not get hold of any specimens of *Anopheles* until August 15. In the stomach of one of these, he found, on August 20, a delicate circular cell containing minute granules of a black substance like the melanin pigment, discovered by Meckel in 1847, which was shown by Virchow and Frerichs to be the essential pathological product of malarial fever, and is found in the malarial parasite. The next morning, he found in his eighth and last *Anopheles* similar bodies, only much larger.

> Both insects had been bred from larvæ in captivity; both had been fed for the first time on the same person—a case of malaria; no such objects as these pigmented cells—as I then called them—had ever before been seen in the hundreds of mosquitoes examined by me; the objects lay, not in the stomach cavity of the insect, but in the thickness of the stomach wall; all contained a number of black granules precisely similar in appearance to those contained by the parasites of malaria, and quite unlike anything which I had ever seen in any mosquito previously. Lastly these two mosquitoes were the first of the kind which I had ever tested. . . . These two observations solved the malaria problem. They did not complete the story, certainly; but they furnished the clue. At a stroke they gave both of the two unknown quantities—the kind of mosquito implicated and the position and appearance of the parasites within it. The great difficulty was really overcome; and all the multitude of important results which have since been obtained were obtained solely by the easy task of following this clue—a work for children.[7]

Shortly after confirming these results, Ross received peremptory orders to proceed to Kherwara in Rajputana, a petty non-malarial station, 1,000 miles distant, which he describes as "my Elba—almost my Île du Diable," for here his researches were interrupted until February, 1898, when he was given a six-months detail to investigate malaria and kala azar in Calcutta and Assam. In the meantime, W. G. MacCallum, at the Johns Hopkins Hospital, had discovered that the motile filaments of *Halteridium,* a parasite in birds, are agents in sexual conjugation, and in 1898, MacCallum and Eugene L. Opie demonstrated the same thing for the malarial parasite. Working with *Halteridium* and *Proteosoma,* both malarious parasites of birds, Ross proved at Calcutta on March 20, that *Proteosoma* can be transmitted from bird to bird by

[7] Ross, *Jour. Roy. Army Med. Corps,* Lond., 1905, IV., 551.

the gray mosquitoes (*Culex fatigans*), which, as he says, "practically proved the mosquito theory of malaria." He confirmed his results by a long series of differential experiments, which he transmitted to Laveran and Manson in letters of April 22, 1898, and after some interruptions, he discovered at Calcutta, on July 8, 1898, that the spores of the parasites were concentrated, not in the intestine, as he and Manson had supposed, but in what proved to be the *salivary gland* of the mosquito.

> The exact route of infection of this great disease, which annually slays its millions of human beings and keeps whole continents in darkness, was revealed. These minute spores enter the salivary gland of the mosquito, and pass with its poisonous saliva directly into the blood of men. Never in our dreams had we imagined so wonderful a tale as this.[8]

In confirmation of this, he infected a large number of sparrows with *Proteosoma* from gorged mosquitoes and his results were communicated by Manson to the British Medical Association in July, 1898. They attracted wide attention among the scientific experts but were absolutely ignored by the governmental and military authorities. Colonel Ross, his financial resources exhausted by these investigations, determined upon leaving India and returned to England in February, 1899. Shortly afterward, he was appointed first lecturer on tropical medicine at the newly created Liverpool School of Tropical Medicine, and here a new phase of his life work began.

In this year (1899), the Italians B. Grassi and A. Bignami gave conclusive evidence that the malarial parasites develop only in the *Anopheles* mosquito[9] and the causal relation was now definitely established. The next step lay in the direction of preventing the disease.

In August, 1899, Ross was sent out by the Liverpool school to investigate the West African coast fevers at Sierra Leone. Landing there on August 10, he soon found that two species of dapple-winged *Anopheles* (*A. costalis* and *A. funestus*) are the agents of transmission, and he immediately proceeded to establish for the first time the fundamental principles of the prevention of tropical malaria, viz., the culicidal treatment of the stagnant pools which were found to be the breeding places of *Anopheles,* scrupulous drainage of the soil, screening of buildings with wire gauze, isolation of the sick, and the habitual employment of mosquito nets and punkahs by individuals. In 1901, he fitted out another West African expedition to Lagos, which, owing to the unscientific, unpractical and unenthusiastic attitude of the government, was paid for by private philanthropy. At Lagos, the marshes were filled up with sand from the lagoons, wire netting for houses and cinchonization of individuals were instituted, and an annual subscription of £150 was obtained from the leading merchants for the organization of a mosquito brigade,

[8] Ross, *op. cit.*, p. 572.

[9] B. Grassi and A. Bignami, *Ann. d'ig. sper.*, Roma, 1899, N. S., IX., 258-264.

concerning which Ross wrote the first scientific treatise in 1902.[10] On the Gold Coast, in 1901, the streets were thoroughly drained, hollows in the ground were filled with rubble and earth, and all breeding places for mosquitoes were obliterated in 5,000 houses at Free Town. The British Bank of West Africa even opened a tropical sanitation fund. All this was accomplished through the propagandism of the Liverpool School of Tropical Medicine. But the crown of its achievement was to come at Ismailia, where, for the first time, assistance was obtained from the government itself. Ismailia, a sleepy, picturesque little town, on the shores of Lake Timsah, destined by De Lesseps to be the headquarters of the Suez Canal Company, was supplied with fresh water by a shallow canal from the Nile, built in 1877 and deepened for the passage of canal boats in 1882. This canal being further used to irrigate the desert and the outlying parks and gardens, much of the water ran to waste forming shallow marshes and ponds in and about the town.

> With the marshes came the mosquitoes; and with the mosquitoes came the fever, and with the fever came—the downfall.[11]

When malaria first appeared in 1877, there were 300 cases from August to December, out of a population of 10,000. By 1891, nearly 2,500 cases were reported and about 2,000 cases were treated annually. The town fell into decadence.

> Men, both Europeans and natives were unable to work, children were always ill, the death rate increased, while the birth rate fell. Every one was down with fever, and trade was soon at a standstill. The government offices were closed and were ultimately moved to Port Said.[12]

Ross arrived at the Suez Canal on September 12, 1902, in company with Sir William MacGregor, governor of Lagos, and immediately set about the task of mosquito reduction. The shallow pools and puddles the gardens and yards, and the cesspools under the houses were obliterated or treated with petroleum by the mosquito brigade, the marshes were drained, the canals and channels were cleared of reeds and other obstructions to flowing water, all water vessels, tubs and flower vases were emptied systematically, all breeding places of anophelines were visited and treated at stated intervals and penalties were imposed upon the townspeople who neglected to report faulty conditions. After an expenditure of 50,000 francs ($10,000), the anophelines were destroyed, and malaria disappeared, but an annual outlay of about $5,000 is necessary to keep the place healthy for "if the mosquito brigade stops work for a week, the mosquitoes return." The natives now call Ismailia "El turba e' nadeefa" (the clean tomb), because, like ancient Greece, it has never recovered from the blow dealt by malaria.

[10] Ross, "Mosquito Brigades and How to Organize Them," London and New York, 1902.

[11] Ross, "The Prevention of Malaria," Lond., 1910, p. 500.

[12] *Op. cit.*, p. 500.

Similar results were obtained at Port Said, Cairo, Khartoum, in Italy and Greece, in the Federated Malay States, in the West Indies, Panama, and elsewhere. In 1906, at the request of the Lake Copais Company, Ross investigated malaria in Greece, where the language itself created a natural bar to statistical information. He found a valley population of two and a half millions with 250,000 cases and 1,760 deaths. In 1905, there were 960,000 cases and 5,916 deaths. The average number of cases throughout the kingdom was 29 per cent. The Anti-Malaria League, founded by Constantinos Savas in 1905, has gone far toward making the ultimate control of the disease possible. Equally effective was the work of Angelo Celli and the Italian Anti-Malaria Society begun in 1899. As Sir William Osler wrote to the *Times* in 1909:

> In Professor Celli's lecture-room hangs the mortality chart of Italy for the past twenty years. In 1887 malaria ranked with tuberculosis, pneumonia, and the intestinal disorders of children as one of the great infections, killing in that year 21,033 persons. The chart shows a gradual reduction in the death-rate, and in 1906, only 4,871 persons died of the disease, and in 1907, 4,160.

Robert Koch's work at Stephansort, New Guinea, in 1900, turned a hotbed of malaria into an absolutely healthy colony by the exclusive use of quinine and his methods were successfully applied in the other German possessions. One great discovery of Koch's was the extraordinary prevalence of tropical malaria in children, which enabled him to attack the disease almost at its source. In 1902–5, Captain Charles F. Craig showed that intra-corpuscular conjugation in the malarial plasmodia is the cause of latency and relapses of the disease, whence it was shown that malarial fever can be transmitted by human "carriers," apparently free from the disease themselves. The discovery of the rôle of the *Stegomyia* mosquito in the transmission of yellow fever by Carlos Finlay (1881) and its scientific demonstration by Reed, Carroll, Lazear and Agramonte in 1900, led to the elaborate and successful prophylactic measures by the United States Army in Cuba and Panama, which included of course the obliteration of malarial fever. A full account of anti-malarial work in all countries is given in "The Prevention of Malaria" (1910) by Ross and his colleagues.

To sum up Colonel Ross's achievement in the science of infection, he devised his own methods for collecting, classifying, feeding, breeding and dissecting the mosquitoes investigated by him, located the species *Anopheles* as the probable true vector of malarial fever, showed that the moonshaped variety of the malarial parasites is found in the body of the *Anopheles*, that the spores of the parasites are concentrated, not in the intestines, but in the salivary gland of the insect, and that analogous parasites may be transmitted from bird to bird by mosquitoes, thus making it possible for Grassi and Bignami to prove conclusively that the malarial parasites develop only in the *Anopheles* and that the disease is

transmitted by this mosquito from man to man. Having demonstrated this hypothesis by induction, he then proceeded to employ his theorem deductively, as applied science, with brilliant success, in the prevention and eradication of malarial fever in West and North Africa.

Colonel Ross kindly gives the following personal reminiscences [sent to Dr. Garrison after General Gorgas's departure for South America, June, 1916].

As every one knows, the Americans started their important sanitary work at Panama early in 1904 under the distinguished management of Colonel (now General) Gorgas, U. S. Army. He invited me, on behalf of the American government, to visit the Canal Zone in order to witness his measures, and as I was also asked to read a paper at the Congress of Arts and Sciences held in connection with the great Exposition at St. Louis, 19th–25th September, 1904, I determined to visit Panama after the Congress was over. At the end of the Congress, each of us who had read papers was given the sum of five hundred dollars to pay for our expenses in traveling over to St. Louis and returning, and we pouched this sum in notes with considerable satisfaction. Unfortunately many of us had scientific friends in the states, and I fell into the clutches of Dr. (now Sir William) Osler who swept me off to Baltimore. After a very warm time with him in that city, I fell into the hands of other friends who passed me on from Philadelphia to New York and left me so little leisure to spare from hospitality that I could not get my five hundred dollars banked or converted into an exchange note. I was then rushed on board ship where I met Colonel Gorgas himself (who was not going to Panama with me) and was duly photographed and speeded on my journey with the good wishes of my many friends. A week later, after a delightful voyage, I arrived in Colon with my five hundred dollar notes still in my pouch. We were immediately sent across the Isthmus and arrived at Panama the same evening. The weather was extremely hot, with the usual result on my nervous system that I became very sleepy and lazy. On arrival at Panama, I was ushered into the Medical Officers' Mess. Now this was a teetotal mess, and I am not a teetotaller by profession, though, I hope, always very moderate in my devotion to god Bacchus. They gave us beef-steak and iced water for dinner, and I became so extremely sleepy after this diet that when I went to my sleeping quarters in a house near the hospital, occupied by Captain Lyster, United States Army, I determined to go to bed at once (within my mosquito netting) and sleep off my fatigue. Lyster did the same thing and we slept beautifully all night. Unfortunately I was so overcome with the beaf-steak and the iced water that I left my pocket book containing my five hundred dollars on the table at the foot of my bed, though fortunately I kept my watch in the pocket of my sleeping jacket. There was a considerable wind all night which kept the doors slamming or creaking, and I was too indifferent to the world to care what happened. When we woke in the morning we were entirely refreshed and as strong as lions in consequence of the beef-steak; but Lyster ran in to my room with alarm written on his face. Sure enough my clothes had been thrown about the room in a terrible manner and my cigar case was found empty in the bathroom. He said that his best suit of blue serge clothes had unaccountably disappeared. We presently heard wailings from all round, and Dr. Balsch, the Health Officer of Panama rushed in from the next house to say that his valuable gold watch had gone. Then I bethought me of my five hundred dollars and ascertained that my pocket book had also disappeared entirely. The fact was that all our houses had been raided that night by an expert gang of house-breakers, who had taken my money and the numerous valuables from my friends.

I was not worried about my loss, because, fortunately, I had asked my agent in England to put a sum of money at my disposal in case of need with a New York bank. Hence, though my friends offered to give me any cash I liked, I refused their offers, and lived for a week in Panama entirely on hospitality with the assistance of a few dollars in my breeches' pocket. Really I was never more happy in my life, and felt the complete joy of being an absolute pauper. At the end of my visit I went on board the same ship, which was to take me back to New York. As I had no money on board the ship I remained equally happy during the voyage, but just as we reached New York my sole remaining hat was blown into the sea. I therefore arrived at New York on a Saturday, with one dollar in my pocket and no hat. Nevertheless I presented myself at the Waldorf-Astor Hotel and asked them to take me in on credit only till Monday. They lent me some cash to buy a hat and fed me as if I had not been a pauper at all. Next Monday my happiness ceased again, because the bank accepted my credit-note from London and filled my pockets with the detestable stuff on which we live.

I believe that none of us ever got back our losses, but the fun of the business repaid me. I believe that I was the only pauper who had ever been the guest of the Great American Republic.

I say nothing here of the extremely interesting time I had in Panama. My only grief was that Colonel Gorgas was not with me; but Captain Lyster, Dr. Balsch, Colonel Carter, Dr. Ross, Mr. Le Prince and every one else gave me the best time imaginable, but generally on a teetotal basis! I ascribe my loss entirely to the somnolence induced in me by teetotalling, and have abandoned that calling ever since.

The most bitter irony of the business was that, when I arrived in Liverpool, my friends there refused to believe that my five hundred dollars had been stolen at all and averred that it had all been thrown away in wild dissipation with Sir William Osler and other congenial friends, so that I obtained the reputation of being, not a teetotaller, but a wastrel.

Ronald Ross

26th June, 1916.

Ronald Ross is a man of remarkable versatility. He is not only a parasitologist and sanitarian of proven abilities, but also a mathematician, a poet and a publicist. He is editor of *Science Progress,* and one of the editors of *Annals of Tropical Medicine.* In 1905, he introduced his method of solving equations by "operative division,"[13] a modification of that discovered by Michael Dary, a gunner of the tower of London, on August 15, 1674, and communicated by him in a letter to Newton on that day. The rationale of this method consists in expressing an algebraic operation as a "verb function," an action upon or arrangement of quantities, without stating the quantities themselves. It is thus one of the symbolic or substitution algebras which have played such a prominent rôle in modern mathematics. Ross defines an algebraic operation, some particular grouping or arrangement of quantities, as a verb, while a function, the result of such grouping, is definable as a substantive or noun. He holds that this notation gives the power of expressing any algebraic operation without reference to the quantities employed, *e. g.,* if o denote

[13] Ross, *Proc. Roy. Irish Acad.,* Dubl., 1905, XXV., Sect. *A,* No. 3, 31–76.

an operation as a verb function, then o^n will denote the operation of raising a quantity to the nth power, when $[o^n]x = x^n$, and since o^0 is unity, $[ao^0 + bo^1 + co^2]x = a + bx + cx^2$. In all this, Ross modestly regards himself as an amateur, but he believes that Newton himself may have adapted Dary's principle in devising his own method of obtaining the roots of equations by approximation. In Ross's operative division, each term of the quotient operates on the whole divisor instead of being multiplied into it, as in ordinary algebraic or arithmetical division. The rest of Ross's mathematical work has been concerned with "pathometry," a term of his invention signifying the quantitative study of parasitic invasion and infection in individuals or groups of individuals. He has investigated, for instance, the variations of mosquito-density in relation to time and place, the relation of mosquito output to extent of breeding surface and the relations of mosquito-density to the rate and extent of malaria-incidence in a given locality; also the relation of malaria-rate to such factors as parasite-rate, spleen-rate (number of malarial cases with enlarged spleen), fever-rate, and the proportion of people who are constantly ill from malarial fever, all of which are lessened by "mosquito reduction." This work on mosquito distribution is said to have been the inspiration of the mathematical memoir of Pearson and Blakeman on random migration. Latterly, Colonel Ross has occupied himself with the study of epidemic curves, that is, the graphs predicting the course and probable duration of an epidemic from its initial data, which were first investigated by the English statistician, Dr. William Farr, in 1866. Work of this kind has been attempted only within the last sixty years, the explanation being that there have been few vital and medical statistics covering large averages until recent times. In the eighteenth century, Daniel Bernouilli applied the calculus of probabilities to smallpox epidemics and got an equation giving the number of survivors who have not had the disease in terms of the number surviving at a given age out of a given number, the number attacked and the number not attacked in a year. The recent aim has been to discover the law of which an epidemic, in relation to space and time, is to be regarded as an expression. In other words, while the hygienist aims to influence and limit the course of the epidemic by such coefficients as vaccines, sera, destruction of insects or animals carrying the disease, or other aggressive sanitary measures, the aim of the modern epidemiologist is statistical prognosis or the prognosis of infectious disease on a grand scale. The strong point made by Farr was that the theoretical curve of an epidemic in space and time is a normal curve. The generic idea is that all recurrent natural phenomena, *e. g.*, the weekly ratio of illegitimacy to the normal birthrate in a large city, tend to acquire a certain uniformity. Farr's law states the general epidemiological principle that subsidence

along a definite line is a property of all zymotic diseases. During the cattle plague of 1865–6, Mr. Lowe in the House of Commons (1866), predicted an epizootic of tremendous proportions, with a formidable rate of increase. His views were controverted by Dr. William Farr in a letter to the *Daily News* of February 17, 1866,[14] in which it was maintained that the rate of increase would begin to decrease rapidly at a certain point, after which it would go on decreasing until the rate of incidence itself decreased. This generalization, the facts of which are not unlike the phenomena of depopulation in modern states, is known as Farr's law. It implies, as Farr says, that "the curve of an epidemic at first ascends rapidly, then slowly until it attains a maximum, then makes a turn and falls more rapidly than it mounted." To prove his case, Farr plotted a bell-shaped probability curve of the actual epidemic, based upon reported and calculated statistics, and predicted that it would have an early maximum with a rapid decline, ending in June, 1866. Actually, the epidemic rose to a maximum on February 24, a fortnight earlier than Farr had predicted, but subsided in the early summer, as he surmised, although at a slower rate than his curve indicated. Nevertheless, his calculations, in the face of the public alarm obtaining at the time, were a great advance in epidemiology, what Ross calls "the first *a posteriori* work on epidemics," in which it was attempted to work back inductively to underlying principles from observed and observable data. Farr also applied his principle with success to a subsequent smallpox epidemic. The cause of the constantly decreasing increase has been sought in the gradual lack of susceptible or infective material, *e. g.*, in the effects of vaccination on the Boston epidemic of smallpox in 1721, a view favored by Ross. Another cause, favored by Brownlee, is to be found in Pasteur's theory of attenuated viruses. Pasteur showed that the pathogenic properties of a virus may be increased or attenuated by successive passages through the bodies of appropriate animals, from which he reasoned that the origin or extinction of an epidemic disease may be due to the strengthening or weakening of a virus by environmental conditions, either in external nature or in the bodies of animals. This seems borne out by the thermodynamic conditions governing the virulence of microorganisms. In the bodies of bacillus carriers, the typhoid bacillus is temporarily inactive or inactivated, for the nonce, an insulated "adiabatic" system, in that energy can neither go in nor out of it. In the body of a susceptible person, the same bacillus becomes activated and pathogenic, whence it is reasoned that a nonvirulent strain of a bacillus may become pathogenic under certain conditions in nature. In this way, Sudhoff has attempted to explain the origin of syphilis in Europe. Prior to its appearance as such, in 1494, there had existed a class of lepra-like diseases yielding to mercury, as is shown by old Italian prescriptions of

[14] Reprinted by Brownlee in *Brit. M. J.*, Lond., 1915, II., 251.

1465. These diseases Sudhoff regards as foci of an endemic spirochetosis, which, in persons rendered weak and susceptible by wars, famine and debauchery, became a virulent infection. Sydenham saw European syphilis as a mode of West African yaws, and salvarsan is a true *therapia sterilisans* for the spirochete of yaws. Pasteur's law explains the facts about the great plague of London (1666). When the disease began to abate, vast numbers of people who had fled the city returned, and Pepys, in his "Diary," made anxious predictions as to a possible recrudescence of the epidemic. But this was not the case. The plague had worn itself out, and it is said that some even occupied the beds of plague patients with immunity.[15] Yet, while lack of susceptible persons and attenuation of the specific virus are not identical causes, they may sometimes amount to the same thing. Since Farr's time, mathematical investigations of epidemics have followed two main lines. Brownlee, Greenwood and other English statisticians have applied the skew curves, devised by Karl Pearson, to the analysis and gradation of the statistics of various epidemics, and Brownlee has found that most of the curves evolved are symmetrical bell-shaped curves of the Farr type, with the difference that the curves do not fall more rapidly than they rose, as in Farr's original hypothetical curve of 1866, but more slowly, as in the actual figures of his 1866 epidemic (Pearson's type IV. curve).

Ross's investigations have followed the lines laid down by himself in 1904, and his ultimate aim is to account, not only for the epidemics which have a symmetrical or normal curve, but also for the asymmetry which characterizes many epidemics influenced by external forces. He divides infectious diseases into three classes: "(1) diseases like leprosy or tuberculosis, which vary little from month to month, but may slowly increase or decrease in the course of years; (2) diseases like measles, scarlatina, malaria and dysentery, which are constantly present in many countries and flare up as epidemics at frequent intervals; and (3) diseases such as plague or cholera, which disappear entirely after periods of acute epidemicity." Concerning the diseases of the second class, he inquires whether they may be due to "a sudden and simultaneous increase of infectivity in the causative agents living in infected persons, or to changes of environment which favor their dissemination from person to person, or merely to the increase of susceptible material in a locality due to the gradual loss of acquired immunity in the population there." It is known, for instance, that measles has occurred at Perth regularly every sixteen months during the last forty years, with but two variations; in Glasgow, every fifteen and a half months up to 1800, and every twenty-four and a half months from 1855 on; while the London records of measles during 1840–1912, indicate a periodicity of about 1⅞ years.[16]

[15] J. Brownlee, *Proc. Roy. Soc. Edinb.*, 1905–6, XXVI., 486.

[16] *Brit. M. J.*, 1915, II., 652.

The coefficients which Ross introduces are the measures of variation due to mortality, natality, immigration and emigration of the non-affected and affected persons respectively. From a set of equations containing these coefficients, the total population and the ratio of the affected to all its members, he gets an equation giving the proportion of the total population affected at a given time.[17] The curve of which this equation is an expression is, in the simplest case, the regular bell-shaped curve, in other words, the assumption that the infectivity ratio is constant or proportional to the number of persons affected gives curves which are not irreconcilable with the hypothesis of decline from exhaustion of susceptible material, opposed by Brownlee. These studies in "à priori pathometry," still to be completed, give Ronald Ross a distinguished place in the modern English school of iatromathematicians.

In 1906, there appeared a little volume of verses with the title page "In Exile, by R. R. Privately Printed," of which the author says, in his preface,

> These verses were written in India between the years 1891 and 1899, as a means of relief after the daily labors of a long, scientific research.[18]

In a sympathetic review of this book, Dr. Weir Mitchell, a fellow medical poet, has said:

> In any climate and under the most indulgent conditions, what he did would have been remarkable. In India the lack of sympathy on the part of his military superiors, abrupt army orders, limited means and absence of help seemed ever ready at his happiest approach to success to mock him with delays. He must have felt as if, at times, some malign fate stood ready with obstacles over which no energy, no self-assurance of ultimate victory could prevail. I know of no medical story more interesting, no research which so surely found what it exacted, that heroism back of which lay energizing sense of duty. . . . Ronald Ross, when half blind or exhausted with work, turned to verse and sought in a difficult field for the relief that change of mental occupation affords, for the making of good verse is not an easy occupation, as several of the greatest poets have confessed. This little book is an interesting record of moods of mind, of hope, despair, sorrow and final triumph. It gives one a vivid conception of the effects of exile, personal losses and the torment of tropical conditions on a man with an imagination of high order, somewhat lacking for use in verse that which only much technical training can supply. There are many verses in this book which exacting self-criticism might have altered or left out. There are some easily amended defects of rhythm—verses which are needlessly obscure; but these concern me little. There are many quatrains of virile power, descriptions of eloquent force or notable passages of insight and deep feeling.[19]

Of Ronald Ross's poems, space permits the citation of but one, the

[17] Ross, *Proc. Roy. Soc. Lond.*, 1916, Ser. *A*, XCII., 207; 211 et seq.

[18] Colonel Ross has recently presented to the Surgeon General's Library his youthful dramas "Edgar" and "The Judgment of Tithonus" (Madras, 1883), "The Deformed Transformed," and the following books of original verses, viz., "Philosophies" (1909), "Fables" (1907), "Lyra Modulata" (1911) and "The Setting Sun" (1912).

[19] Mitchell, *Jour. Am. Med. Ass.*, Chicago, 1907, XLIX., 852.

verses written on the day upon which he discovered the malarial parasite in the body of the mosquito:

This day relenting God
  Hath placed within my hand
A wondrous thing; and God
  Be praised. At his command.

Seeking His secret deeds
  With tears and toiling breath
I find thy cunning seeds,
  O million-murdering Death.

I know this little thing
  A myriad men will save.
O Death, where is thy sting,
  Thy victory, O Grave!

Before Thy feet I fall,
  Lord, who made high my fate;
For in the mighty small
  Is shown the mighty great.

In his work as a sanitarian and eradicator of disease, Sir Ronald Ross has waged valiant and efficient warfare against the indifference and apathy of organized governments toward applied science, that medieval frame of mind so well described by Sir Clifford Allbutt:

We find, in ruling classes, and in social circles which put on aristocratical fashions, that ideas, and especially scientific ideas, are held in sincere aversion and in simulated contempt.

Time and again has Ronald Ross returned to the charge in his general assault on unscientific administration in regard to the prophylaxis of infectious disease. His utterances on this theme reveal him as a publicist of large-minded type. Nothing seems more characteristic of the man than his general view of the whole matter:

Probably few any longer accept the teaching of Hume, that the object of government is no other than "the distribution of justice." The function of an ideal civilized government might be described as the performance of all acts for the good of the public which individual members of the public are by themselves unable to perform—that is, the organization of public welfare. The individual can certainly add much by intelligence and virtue to his own welfare; but these qualities do not suffice to protect him altogether against those evils which can be combated only by concerted action, such as the depredations of disease and of external and internal human enemies; and where he is powerless, the government, and only the government, can help him. Now such concerted action is likely to be successful only when it is based on sufficient knowledge; and a scientific administration differs from an unscientific one just in this particular, that it seeks the necessary knowledge, while the other acts blindly. In nothing is this more manifestly the case than in connection with that department of public administration which is charged with the protection of the public against disease—a department second to none in importance, because it concerns not only our sentiments and our pockets, but our health and our lives.[20]

[20] Ross, *Nature*, Lond., 1907, LXXVI., 153.

WAR SELECTION IN THE PHILIPPINES

By Dr. EDWIN BINGHAM COPELAND

DEAN OF THE COLLEGE OF AGRICULTURE, UNIVERSITY OF THE PHILIPPINES, LOS BANOS, LUZON

IT has been assumed by writers on the relation of war to racial development—and I am sure the assumption is correct—that fighting has at some time been necessary to keep up the quality of the race. Some kind of struggle, war or economic competition, or something of this kind, must have been necessary to maintain human progress from the time that man acquired such a mastery over the rest of nature that he was spared the necessity of a real struggle with other animals. I have had the impression from some of the early papers of Dr. Jordan that he granted the correctness of this assumption, but believed that modern warfare was peculiar in not having this selection value. This would have implied, even if it were not stated, that the wars of ancient but historical people did have a selection value. This is explicitly denied in "War and the Breed," and is certainly denied with right. In the wars of the Greeks, selection of the best by survival was probably even less likely than it is in the present European war. In the warfare of to-day, the best are eliminated both because they are admitted to the army, and because the brave ones sometimes get a chance to expose themselves; but in the present warfare, there is so little chance to select the enemy to be killed, that the picking of the victims is essentially without any choice whatever. In the warfare of the Greeks, even leaving the Spartan out of account, social custom drove the good citizen to war and forced the brave man to expose himself at almost every opportunity. The brave or the strong man was driven by the full force of social pressure and by his own sense of honor to take every possible risk, and this, of course, eliminated the best more rapidly than would be done by the present war. Beyond this, the man of ability was most dangerous to the enemy, and as a general proposition, there was particular glory to be acquired by killing a notable foe. This placed the best warriors at a considerable disadvantage as compared with their present position.

I note a passage in Thucydides. The Athenians captured a considerable body of Spartans on the Island of Sphacteria. Some of the Athenians were deriding one of the captives and asked him if the ones who had been killed had not been braver men. The captive replied that it would have to be a very wise arrow which could distinguish the brave from the cowardly. His comment would place warfare where it is today, an indiscriminate slaughter of the combatants.

I have had considerable opportunity during twelve years in this part of the world to see the effect of warfare of various kinds on the race. It seems to me that we have in the Philippines illustrations of both

good and bad racial effects of fighting. Our Moro population is one which has made fighting its chief business for centuries. The Moros entered the Philippines in the fifteenth century, and for the 450 years since that time they have not done much except fighting. Because of the school of ethics in which they are brought up, they are the best fighters in this part of the world. Give them the same weapons and they would be practically certain to overcome an equal number of Filipinos. At any rate, if both sides were given primitive weapons, this would be true. From such evidence as we have, it seems safe to conclude that four or five centuries ago, the Moro was the best man in the Philippines in almost every respect. To-day, he is decidedly the inferior of the Filipino for every purpose except fighting. I will make this general statement without any reservation in spite of the fact that the Island of Jolo had a bigger percentage of the population able to read and write fifteen years ago than did any Christian province in the Archipelago. The Moro is uniformly physically inferior to the Filipino, and this is true of both men and women. It is not altogether the Moros' fault that the development of schools has been very backward in the Moro province, but I have had enough experience with individuals to conclude, for myself, that the Moro of to-day is intellectually inferior to the Filipino. Another effect of centuries of fighting is that there is a very conspicuous tendency to prompt degeneration when war is stopped. When the Moro is kept from fighting, as has happened in certain districts, notably around Zamboanga, and is given the same opportunity which the Filipino has had in most places to develop industrially, instead of doing this he becomes as worthless as a human being can be. It may still prove to be possible to develop the Moro industrially, but it is a certain fact that he makes practically no start at all in developing himself. It is this degeneration when the fighting ceases which I would call the most conspicuous evidence of the destructive effect of centuries of fighting. As a matter of opinion merely, I would say that the Moro will admit of being developed. It is my impression from living among various people, that there is very little difference in their susceptibility to development and, to this extent, I believe that even the bad effect of warfare can be overrated. War does more damage by far in removing those who could be leaders in development, and cutting off the capacity for leadership from the following generations, than it does by lowering the capacity for being developed of the body of survivors.

But, we have in the Philippines still other races than Moros and Filipinos. Among these are the Negritos, about whom I know very little. Possibly they are low enough in the scale of humanity so that they can not be developed as well as most people can be. But there are in the mountain districts of Luzon and Mindanao so-called wild people, pure pagans, who have through all the centuries fought among themselves, just as primitive men must have fought through ages, practically

without firearms; and among whom warfare is either hand to hand or with projectiles which are aimed at individuals instead of masses, so that the essential elements of individual combat are still present. Physically, these wild men contain the best people of the Archipelago. Judged in another way, by the strictness with which they observe their own ethical "code," they are also better than the Filipinos. This strictness in observance of the tribal customs is always a function of conditions of constant struggle. In this respect, the pagan and the Moro are alike and the Christian is inferior, because, during the recent centuries, he has been largely spared the necessity of tribal struggle for existence. As to intellectual ability, we have not enough information about the wild men to justify valid conclusions. There have been in recent years a few Igorots of different tribes who have acquitted themselves excellently as students. I have also known Bagobos, and Mr. Elmer reports a different tribe from Mindanao, who have seemed to us to demonstrate decided intellectual keenness in their dealings with nature. But the fact that the Bagobo is keener in dealing with nature than the Filipino may reasonably be the result of his being placed where he has to be keener. Almost every American who has considerable contact with the Igorot regards him as the best man in the Philippines. Knowing both Igorot and Bagobo, I am disposed to rate the Bagobo of the hills above the Igorot. On the other hand, men thrown in intimate contact with the better class of Filipino scout the idea that the wild man of any kind can be compared with the Filipino. Leaving these opinions as matters of mere opinion, the fact is indisputable that the wild man is physically the best there is in the islands to-day. This superiority is not a function of the altitude. Lukban, for an instance, is an excellent Filipino town, and Lipa is another. These are in altitude between the Bagobo settlements of Sibulan and Todaya. The Bagobos could pick the Filipinos to pieces with their bare hands. There is an old Latin proverb which says that a sound mind goes with a sound body, and I am inclined to believe that their mere physical superiority, even reduced to nothing but better health, would give to Bagobos an advantage in fair intellectual competition, with equal preliminary training, with the Filipinos. To at least this extent, it is my opinion that we have among our wild people evidence of the positive value of personal combat, when the struggle for existence takes this form, as a means of racial improvement. These suggestions are of course sent merely as matters of collateral interest as possibly throwing some light on the outer edges of a big subject.

It thus appears that the Moro originally excelled the Filipino in ability; but has become distinctly inferior, physically and in ability to develop in civilization, as a result of several centuries of chronic war. The Bagobo and Igorot (in the broad sense) exemplify the good results of selection by primitive war on the scale of personal combat.

In this article, I do not venture, however, a prophecy that the

Bagobo will ever demonstrate any kind of superiority to Filipino or Igorot. The demonstration depends very much upon opportunity. The Igorots, in the broad and rather inaccurate sense in which I have used the words, are a numerous people capable of maintaining a large measure of independence; and they are now receiving what I believe is competent and efficient help in preparation for intercourse with the outside world. The hill Bagobos are few in number and the interference of government in their affairs has not, in my opinion, been very intelligently calculated to preserve them as a strong race. What the government undertook to do, with the best of intentions and with full recognition of the superior vitality of the Bagobo, was to bring him in contact with civilization by bringing him down out of the mountains. I have not seen these people for a number of years, but could anticipate no result of this policy except that most of the Bagobos would become plantation serfs and the more independent minority would become renegades. This was the work of Lieutenant Bolton, one of the men most conspicuous in devotion to the interests of the people under his charge whom I have ever met. The best of intentions may make the most mischief in the attempt to make a race over and improve its conditions without sufficient appreciation of the fact that the direct ability of the race is adapted to the conditions under which this ability has been developed. Lieutenant Bolton was murdered a little later as the result of another attempt to make a powerful savage into a man of influence under more civilized conditions.

We have naturally made mistakes of the same kind in the well-meant attempt of many of our officials to make good Americans out of good Filipinos. The preservation of order in these islands during the past fifteen years has of course been of tremendous value to the people, and the introduction of a general educational organization, even of such an organization patterned very largely after that of the United States, has been another incalculable service. But the transplanting of a scheme of government, including even features of exceedingly doubtful value in America, has brought with it evils some of which will probably never be peacefully outgrown.

These comments are, of course, not relevant to the question of racial selection. They have, however, a bearing on the conditions which make war the foremost subject of world interest at this time. I am a great admirer of real German culture. I have a certain sympathy with the German ambition (even if its profession by the government may be largely hypocritical) to germanize other parts of the world. The trouble with the scheme, aside from its probable impracticality by the methods being tested, is that what is best for Germany is not necessarily best for England and Borneo, any more than what is best for the United States is necessarily best for the Filipino, or what is best for the Filipino is best for the Bagobo.

ESSENTIALS IN THE STUDY OF LABOR ORGANIZATIONS

By Professor FRANK T. CARLTON
Albion College

THE assumption that all labor organizations may be traced back to some one original form of local trade society is unwarranted. Labor organizations of different types and located in different communities are the products of environmental conditions and forces which have caused the wage-earners to cohere in some weak or strong form of union organization. Because of increasing population, the elimination of free land, rising prices, or other social phenomena, American wage-earners have been vividly impressed with the insufficiency of individual bargaining. Organization is naturally the next step. Wage-earners organize in order that wages may be raised, hours reduced, or conditions of work improved. The form of the organization is not the significant fact; nor is the expressed function of the union whether business, revolutionary or "predatory" of great importance But classification may help students of labor problems in their effort to investigate the complex of union origins, structures, methods and functions.

Organized labor is a social phenomenon; it is a form of institution. The form, methods, ideals and immediate purposes of labor organizations may be studied in the same manner as political parties or fraternal organizations may be analyzed. A union consciously or unconsciously adopts a certain peculiar form or structure in order to aid it in accomplishing certain aims. No institution would come into being were it not intended, deliberately or fortuitously, to affect certain changes in the course of human affairs. And no form of organized labor would exist unless wageworkers hoped to obtain through its agency some improvement in living and working conditions. These statements are certainly little short of axiomatic. In short, both the structure and functions of a labor organization or of any other institution are the visible and tangible results of underlying forces and causes which spring out of the physical and social environment. The analysis of a labor organization is a study in social mechanics. To classify labor organizations according to structure or according to functions may be desirable; but the classifier should remember that he is only dealing with outward manifestations and results, not with causes and fundamental motives.

The union—a social structure or organization—is a grouping of wageworkers for the purpose of accomplishing certain results. The union is a tool; a means to an end. Writers upon the subject of labor and labor organizations have not held that the form of organization was fundamental. Nor have they held that all labor organizations were alike or even similar in ideals and plans. Indeed, quite the contrary is true.

Students of government realize that the term—"a democratic government," for example—must be translated differently in Haiti than in the United States. Nevertheless, classification of governments into republics, constitutional monarchies, and so on, is of value to students of political science. It is doubtless true in a broad way that democratic forms of government are the products of the change known as the industrial revolution. But the existence of danger from outside foes may retard progress toward a democracy, as witness Germany. Or tradition may keep the shell of a government for a long time after its reality has been sloughed off, as is the case in England. In like manner, opposition from without, tradition, or the pressure of leaders, may greatly modify the course taken in evolving the structure and functions of a labor organization.

In the great majority of cases, a given structure or form of a government or of a labor organization more truly represents a past than a present balance of forces; but it is also a factor in determining the present-time attitude of those adhering to the government or labor organization in question. After an institution has been developed and has crystallized into certain forms, this somewhat inelastic structure usually serves as a modifying and conserving force or influence. Group and institutional inertia must be reckoned with in any study of social and institutional forms. American legal and constitutional forms have greatly modified the course of events in American national life. The existence of social customs and habits also tends to prevent rapid changes in ideals. The psychology of the American has undoubtedly lagged behind the unusually rapid changes which have taken place in industry during recent generations. The American workingman has been too individualistic to cope effectively with the great and steadily growing combinations of capital; to many of them yet clings the restless and impatient vitality and self-assurance of the frontier. The effect of social inertia is also plainly visible in the ideals, the concepts and the psychology of the unionist. The psychology of the average unionist is still measurably affected and modified by ideals and concepts crystallized during the outgrown era of small-scale, non-integrated industry. Again, overworked and undertrained workers will have a narrower vision than more efficient and better trained workers. A union composed of the former will be more erratic and less calculating than one composed of the latter type of unionists.

Slavery and serfdom are heritages which the past offers to the wage-earning class of to-day. The prevalent idea that the employee is the "protégé" of the employer is old and dies hard. Organized labor is, in fact, a token of emancipation. In struggling upward toward industrial democracy the workers are seriously hampered by the lingering and still potent ideas and ideals developed during generations of subordination and of non-citizenship. As a consequence, the evolution of the psychology of the wage-earner—the new social psychology—is retarded and

modified by the old and outgrown folkways as to the relation between employers and employees. It is also affected by survivals in the form of rabid and irrational national patriotism, racial antagonisms and concepts as to the desirability of different forms of work and service. The European war conclusively proves that in times of national stress the old catch-words and phrases are more powerful and compelling than the newer ones of social solidarity and loyalty to the working class. But at other times when the life of the nation is not menaced, the phenomenon of union loyalty bulks large among the members of organized labor.

Both the specific structural and the specific functional forms of labor organizations are very diverse. No two types of workers have been subjected to exactly the same economic pressure, the relations between workers and their employers vary greatly in different lines of business, the possibility of displacement by other workers or by machines likewise varies from trade to trade and from occupation to occupation, and price levels and standards of living are subject to rapid modifications. This complex situation is further complicated by the institutional lag exhibited by organizations of labor. And the influence, conservative or radical, of the capable and aggressive leader, must not be neglected. Samuel Gompers, for example, is a factor which can not safely be overlooked in any careful consideration of the evolution of the American Federation of Labor. The autocratic and imperious leader has played an important rôle in labor organizations as well as in the affairs of nations. The appeal to the passions and emotions figure in union matters as well as in party politics.

As a consequence, labor organizations present to the student and to the man-in-the-street a bewildering diversity of structure and of functions. Some of the apparent variations are not real. These are due to the idiosyncracies and preconceived notions of would-be interpreters of unionism. But inevitably the variations are many, because these register the results of the play of a multitude of pushing and pulling forces. Yet, the fundamental desires and motives are comparatively simple.

> The growth of trade-unionism and of what is called the trade-union spirit is a concomitant of industry organized after the manner of a machine process.[1]

The term "machine process" does not, however, necessarily mean the actual use of machines, but it may be applied to all large-scale methods involving wide market areas. As different workers come in touch very differently with the machine process, variant ideals may be expected to appear. This differentiation becomes clear when a comparison for example, of the cigarmakers with the locomotive engineers, or of the machinists with the building trades workers, or of the molders with the migratory workers, or of the miners with the barbers, is undertaken.

[1] Veblen, "Theory of Business Enterprise," p. 327.

Individuals may be animated by altruism and act contrary to their own welfare and happiness in the interest of others; but groups, classes and nations do not. At least, such is the situation up to the present time.[2] Frequently, however, the interests of a group, class or nation may on the surface appear altruistic. And when group interest and altruism run in parallel channels, the emphasis is always placed upon the latter. The selfishness of groups is no new discovery of the social psychologist. Practical politicians have for years and probably for centuries recognized the potent influence of group selfishness. One example may be cited from American history. In 1828, Mr. McDuffie, a well-known South Carolinian, said:

> Individuals are always open to impressions of generosity. But classes of the community, and sections of country, when united and stimulated by the hope of gain, being destitute, like corporations, of individual responsibility, are, like them, destitute of hearts and souls to feel for the wrongs and sufferings they inflict upon others.

Organized workers, like organized capitalists, are organized primarily for group or class betterment. All methods and ideals must stand the acid test of group advancement or retardation. However much we may dislike to look the facts in the face, they will not down. Workers are men and women like employers and animated by the same fundamental human animosities and desires. And the division of unionists into revolutionary and business groups is only one of degree and circumstance. There are in fact no fundamental differences. A so-called business union may under pressure of adverse circumstances become within a few years revolutionary. Or, the reverse change may take place, and a revolutionary labor organization may gradually become more and more conservative under the mollifying touch of prosperity.

Miss Marot[3] has frankly and boldly stated the real demand of the unionist, be he of the business or of the revolutionary type. It is for less work and more pay. This statement from a spokesman of organized labor discloses a clear and distinct line of cleavage between the working-class unionist and the middle-class reformer. But this frank statement rings true whether it be applied to the aristocrats of labor or to the ranks of the unskilled and readily replaceable. Eliminate cautiousness and lack of vision of the goal, and the conservative unionist reveals the same essential longings and desires as his more impulsive and radical brother. And, furthermore, he is not essentially different from his employer who demands more profits without questioning whether more profits mean more or less service to the community.

The attitude of the radical or revolutionary union is well illustrated by a trade union in one of the large western cities. The members of this strong union "recognize no trade or industrial obligation

[2] For a somewhat different view, see Cooley, "Social Organization."

[3] "American Labor Unions," p. 4.

above their allegiance to fellow unionists or to labor. They consider that their contract to stand by labor comes first and takes precedence over all contracts made with capital."[4] Allegiance to the union is placed on a par with national patriotism. No contract obligation is allowed to stand in opposition to group welfare and group requirements. This revolutionary attitude is assumed not only by industrial unions but by organizations of the familiar type of trade unions. The viewpoint of these unionists is similar to that of a nation which is ready to tear up a treaty when confronted by what is considered to be national necessity. Class lines are often drawn as taut as are national lines in times of stress and strain.

On the other hand, conservative railway brotherhoods are ready in case of a strike to counsel a policy of non-interference. But the members of the railway brotherhoods who are conservative and who are very explicit in stating that they do not intend to disturb the present industrial order, are in spite of external characteristics not very dissimilar from the members of radical unions who are extremely bitter in their denunciations of existing conditions, and who are "revolutionary." The difference between the viewpoints of these two classes of unions is not to be explained by resorting to some more or less occult statement of group or social psychology. But it is to be found by analyzing the different economic environments in which the groups work and live, and the different kinds of economic and social pressure to which the groups are subjected. The members of a railway brotherhood occupy a strategic position. It is very difficult to obtain reasonably efficient substitutes in case of a strike. But a union of unskilled men would perforce be obliged to take another stand or suffer their places to be filled by strikebreakers. Put the railway brotherhoods face to face with the menace of the green hand, or with a hostile employer who is nibbling at wages and who refuses to consider granting a standard wage, eliminate their systems of insurance, put the members of these brotherhoods in the position of many another group of wage-earners, and the present much-approved set of ideals will rapidly be replaced by others not so conservative.

Subject the railway brotherhood to the dangers which are and have been for several years confronting certain radical old-line trade unions, and their conservatism and the emphasis now placed upon the sacredness of contract will disappear with celerity. The early history of that much maligned organization, the Western Federation of Miners, furnishes a fine illustration of social transformation. The metal miners of the far west were

confronted by a quickly developed and aggressive class of wealthy mine owners. Control of the mines was suddenly centralized; individual bargaining became futile; the separate and disunited units of labor were sweated. The miners felt

[4] Marot, "American Labor Unions," p. 14.

themselves to be in the grip of a new and strong industrial system. . . . Under pressure, the miners knit together into an industrial class—conscious and avowedly socialistic union; and, remember, these miners were individualistic American frontiersmen.[5]

It must, of course, be admitted that the experience of the unskilled worker with the machine process will modify his viewpoint somewhat and make him more susceptible to influences which cause the growth of group or class solidarity.

The structure of the American Federation of Labor and its constituent parts is gradually changing. This modification is not due primarily to a new group psychology. It is, however, true that the mixture of racial elements in the Federation is somewhat different than it was ten years ago. Nevertheless, the significant factors are the changed industrial situation, the reduction of many kinds of workers to a common denominator by the use of the machine, the fierce opposition of employers, and the like.

The form of organization is indeed no minor matter. The trade union is an antiquated weapon in the fight against the big corporation unless the skill of the trade is still a potent factor or some other special place of vantage remains. To meet the mighty German army with the weapons of the Civil War spells ignominious defeat. To combat for higher wages and shorter hours with the defenses of 1866 likewise means defeat. The trade union is the fundamental and most natural grouping of workers for betterment. In the trade union are united workers engaged in similar work and interested in similar matters. Carpenters have more in common with other carpenters than with boilermakers or molders. But as the machine process undermines trade after trade and tends to reduce all workers to a common denominator, trade or craft becomes of less and less importance. And as carpenters, molders and boilermakers become united as employees of the same corporation, trade lines yield to the unity of interests as employees of one big business organization. As a consequence, organization by industry begins to replace organization by trade. The structure changes and the specific function of the organization may undergo modification; but the fundamental purposes of organization do not undergo great transformations.

It may therefore safely be asserted that the prime factors in a study of labor organizations, are not: Is the union a trade or an industrial union? Or, is its purpose business or revolutionary? The important questions are: Why has it adopted the ideals, form and methods which are now associated with the organization? And, what are the internal and external, present and past, forces which determine its path to-day? Any classification whether structural or functional is only of value in making clear the factors in the labor problem. A study of social forces is essential in any investigation of labor organizations.

[5] Carlton, "The History and Problems of Organized Labor," p. 108.

THE ENVIRONMENT OF THE APE MAN

By Professor EDWARD W. BERRY
JOHNS HOPKINS UNIVERSITY

AT that late epoch of the earth's history which immediately preceded the development of continental ice sheets, or the Pleistocene Glacial period in North America and Europe, we find but little evidence of what the next few thousand of years had in store for the rich terrestrial faunas and floras that had spread from Gibraltar to Korea and probably across the Bering land bridge between Asia and America, and over a part of the latter continent.

The Pliocene age, as the era immediately preceding the Glacial period is termed, probably witnessed the most profuse and diversified mammalian life and arborescent flora that the world has ever seen. The fauna, sometimes known as the Hipparion fauna, from the abundance at that time of the small fleet horses of the Hipparion type, is somewhat better known than the flora for the whole eurasian area, although for the area of Europe the flora is very well represented at a large number of localities. The fauna as shown by the accompanying sketch map (Fig. 1) has been traced from the Tagus Valley on the west to Korea

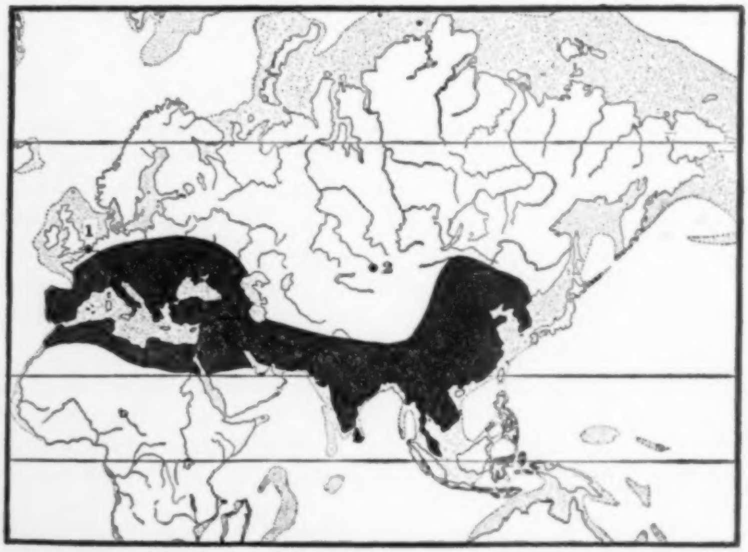


Fig. 1. Sketch Map Showing Range of the Pliocene Hipparion Fauna and Greater Extension of the Flora. 1, Pliocene flora of Holland-Prussian border. 2, Pliocene flora of Altai region.

on the east, through 140 degrees of longitude or a distance nearly half way around the world.

The flora has been found at very many localities in Europe associated with this fauna—in Portugal, France, Italy, Germany and throughout the Austrian empire. The less precise work, or possibly the absence of as good material because of the inadequate facilities for preservation in the river floodplain deposits of Asia has hitherto prevented the assembling of data regarding the Pliocene flora of the latter continent. In both Europe and Asia, however, this flora is found beyond the known limits of the fauna. A notable instance is that furnished by the plant remains found in the brick clays of the Holland-Prussian border and recently monographed by Clement Reid[1] and Laurent.[2]

This remarkable flora contains upwards of 300 species and shows a striking similarity to the living flora of the uplands of western China and to its more or less allied geographical provinces, *i. e.,* Japan, the Himalayas, eastern Tibet and the Malay Peninsula. A more remote relationship is shown with the existing flora of Europe or the Caucasus, and a still more remote relationship with the existing flora of North America.

This oriental character, using that term in the sense of its application to existing floral distribution, is shown by the presence in Limburg during the late Pliocene of forms like *Gnetum scandens, Zelkowa keaki, Pyrularia edulis, Magnolia kobus, Prunus maximoviczii, Stewartia pseudo-camellia,* etc., no longer natives of Europe, as well as by representatives of genera such as *Meliosma, Actinidia, Corylopsis, Camptotheca,* etc., not found in the existing European flora but represented by closely allied species in China. Even when the genus is still a member of the European flora, the fossil species appears to be closer to the existing Asiatic rather than the existing European representative, as, for example, in the genera *Pterocarya, Styrax, Betula, Cornus, Clematis, Eupatorium,* etc. There are among the fossils, however, a number of large-seeded forms that are still represented in the flora of Europe, among which may be mentioned *Picea excelsa, Quercus robur, Carpinus betulus, Corylus avellana, Prunus speciosa, Ilex aquifolium, Vitis vinifera* and *Fagus* cf. *silvatica.*

[1] Reid, C., and E. M., "Preliminary Note on the Fossil Plants from Reuver, Brunssum and Swalmen," *Tijdsch. Kon. Ned. Aardrijks. Genootschap,* 2e ser., Deel XXVIII., afl. 4, 1911, pp. 645–647; "The Pliocene Floras of the Dutch-Prussian Border," *Mededeelingen Rijksopsporing van Delfstoffen,* No. 6, The Hague, 1915, 178 pp., 4 tf., 20 pls.

[2] In Jongmans, W., "Rapport over zijne paleobot," *Rijksopsporing van Defstoffen,* Jahren 1908–11, pp. 23–25; Laurent, L., "Note preliminaire au sujet des plantes pliocenes des argiles du gisement de Reuver et des gisements voisins," Ibidem, Jahren 1914, 4 pp., 1915.

The Reuverian flora, as it has been called, appears to indicate a climate about like that of southern France of the present time, but with a more abundant rainfall. It was richer in species than the present flora of central Europe and the number of arborescent forms was greater, both relatively and absolutely, comprising fifty per cent. of the determined forms. A somewhat similar Pliocene flora was described some years ago from the Altai Mountains[3] in Central Asia. In the latter region were found sequoias, alders, oaks, beeches and tulip trees of North American character associated with oriental beeches, walnuts and maples, as well as with various other trees now characteristic of Mediterranean Europe.

These late Pliocene floras are frequently spoken of as cosmopolitan floras and in the sense that throughout the whole Holarctic region there was not then the geographical differentiation that is displayed by the existing floras this term is true. It does not mean that the semi-arid plains of Algiers had identical species with the forested glades of southern France or that the tropical forests of Indo-China were identical with those of the Asiatic steppes, but there were no well-marked provinces—in Portugal, France, Italy and the Altai we recognize the familiar types like the Sassafras, Magnolia and Tulip tree, which to-day are confined to southeastern Asia or southeastern North America.

This in brief was the setting in which were inaugurated those climatic changes so striking in their results, but probably not nearly so extreme in their actual changes, that resulted in covering so much of Europe and North America with a continental ice sheet many feet in thickness. This was also the setting of that event, great from our human standpoint, when somewhere in the orient the ape-like ancestors of man passed the intangible bound that separated apedom from incipient manhood, for in the older Pleistocene of the island of Java we find the oldest known fossil remains of such an ape man, the *Pithecanthropus erectus* of Dubois, associated with the bones of a large contemporary fauna; and the foliage, fruits and wood of the valley forest in which these remote ancestors of ours dwelt.

The exact age of the strata containing the remains of *Pithecanthropus* is of the greatest importance and on this point as well as on the questions of the environment and climate the fossil flora is much more definite and conclusive than the associated vertebrate and invertebrate fossils. Let us then endeavor to picture the surroundings of the ape man and the animals and plants that spread with him into Java from the river valleys of the Brahmaputra and Irawadi, two thousand miles or more to the northwest, and something of the geography and topography of the lands through which they wandered.

The Pleistocene was in general a time of receding oceans and broad-land connections. Some think that this fall in sea-level was due to the

[3] Schmalhausen, J., "Palæont.," Bd. 33, 1887, pp. 181–216, pl. 18–22.

great amount of water that went into the formation of the ice sheets; at any rate, we know that all the continents were connected, a wide land bridge extended from Asia to North America across Bering sea. In the southeastern Asiatic region the shallow southern half of the China sea, the Gulf of Siam and the shallow Javan sea were all dry land—vast, fertile and well-watered plains teeming with life. Sumatra and Java were connected with Borneo and the Malay peninsula and formed a part of a broad eastward extension of land that reached to and included Timor, the present eastern outpost of the spice islands. These seas are still so shallow that ships can anchor in any part of them.

The Menam River was lengthened a thousand miles and flowed through the Gulf of Siam and sweeping around to the northeast discharged into the China sea. A great Javan river with its headwaters in the vicinity of the straits of Malacca flowed eastward and southward, receiving many large and small tributaries from the uplands of Borneo and Sumatra. It flowed in a broad and densely forested valley extending for a thousand miles along the bed of the Java sea and emptied into the Flores Gulf. The mountain axis of Borneo continued northward nearly or quite connected with Luzon by the enlarged Palawan and Mindoro islands. The Sulu archipelago was a part of western Mindanao and nearly or quite reached north Borneo. The Sangir islands were connected with the northern arm of the Celebes and nearly or quite reached Mindanao while a narrow strait separated Celebes from Borneo, widening north of the former to form the Pleistocene Celebes sea. The Andaman and Nicobar island festoon was connected with lower Burmah forming the large and almost land-locked Gulf of Burmah. The mountain axis of Sumatra was continuous across Java and on to the eastward, for the fault which formed the narrow Sunda Strait between the two islands was not yet in existence. The Pleistocene was also a time of great volcanic activity in this whole region. Java has about 125 volcanic centers many of which are great peaks, but only 13 of these are feebly active at the present time. During the Pleistocene volcanic activity was at a maximum, as is shown by the fact that not only 28 per cent. of the present area of Java consists of these rocks, but most of the remaining area is made up of sediments that are largely volcanic débris. I have endeavored to picture the probable geography of the early Pleistocene in the southeastern Asiatic region in the accompanying sketch map (Fig. 2).

During the early Pleistocene broad and fertile river valleys extended from the Punjab eastward and southward. From the sharp turn in the Brahmaputra at Sadiya in Assam great valleys or verdant coastal plains flanked by salubrious uplands extended southeastward for a distance of between two and three thousand miles and it was along these coastal plains and valleys and the parallel mountain ridges that upland and

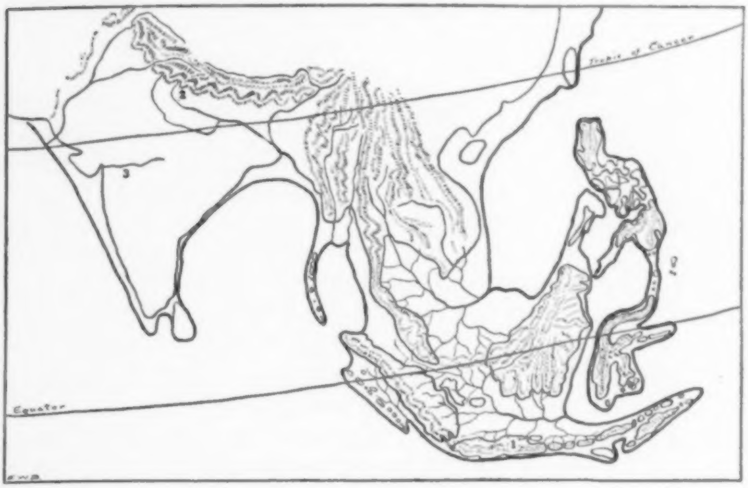


FIG. 2. SKETCH MAP SHOWING PROBABLE LAND CONNECTIONS IN THE SOUTHEASTERN ASIATIC REGION IN THE EARLY PLEISTOCENE. 1, Location of Trinil fossil faunas and floras. 2, Location of Pliocene Siwalik faunas. 3, Location of Pleistocene Narbada faunas.

lowland animals and plants were able to spread simultaneously toward the southeast. The relative elevation of the Himalayan region and a slight lowering of temperature combined with the pressure of population were sufficient to cause this organic flood to gradually spread to the southward.

The *Pithecanthropus* or Trinil men as pictured to us by the anthropologists were of low intelligence, as is indicated by the slight development of the frontal region of the brain, by their cranial capacity of from 850 to 900 cubic centimeters as compared with 600 cubic centimeters for the largest simian brain and 1,200 cubic centimeters for the Neanderthal men of the Third Interglacial period. From a study of the inside of the cranium of the Trinil man it is estimated that the lower frontal lobe, the speech center, was twice as well developed as in any existing anthropoid ape, but still only about half that of Modern man, so it seems certain that the Trinil race possessed at least a rudimentary power of speech.

The remains of the fauna that was contemporaneous with the ape man include fifteen species of land and fresh-water snails and river clams, all of which are still living and in the same general region at the present time. There are several genera of fresh-water fishes; a gavial very close to the existing armored crocodile of the Ganges and a true crocodile close to the existing crocodile of Java and Borneo. Five river and swamp turtles have been described, all similar to living types of farther India and the Sunda islands. Among the birds were parrots

and marabouts. Over a score of mammals, a typical forest and stream border assemblage, have been described. These comprise a macaque, several carnivores including both dogs and cats, two rhinoceroses, a hippopotamus, two wild hogs, several deer including the Sambar deer of India and the Kidang deer still living in Java, buffalo and wild cattle, the porcupine, a large pangolin and hyena, a tapir like the existing Sumatra tapir, and at least three elephants—a *Stegodon* and an *Elephas*, both close to Indian species of the Pliocene (Siwalik) and Pleistocene (Narbada), and another *Elephas* like the straight-tusked *Elephas antiquus* of the early European Pleistocene. This fauna as well as the associated flora are conclusively continental instead of insular in character and were clearly derived from the northwest.[4]

Dubois discovered the remains of *Pithecanthropus* in 1891 along the Bengawan or Solo River near the little hamlet of Trinil in east central Java. To the north are the low east and west range of the Kendeng Hills, to the south lies the high cone of the volcano of Lawoe. His discovery excited the greatest interest and a vast literature has centered around the ape man long thought to be Pliocene in age. During 1907 and 1908 the Selenka expedition made careful excavations at Trinil with the object of supplementing Dubois's scanty material, collecting many vertebrate remains and also the fossil plants which throw such a welcome light on the exact age and environment of the ape man, but failed to find any additionl *Pithecanthropus* remains. The deposits are fluviatile with little regularity in the sequence of bedding and consist of alternating lenticular beds of volcanic débris (lapilli and ashes) sometimes clayey and sometimes sandy, with a total thickness of about 50 feet. The general sequence is as follows:

Recent alluvium.

Kendeng beds:
- Red ashes and lapilli.
- Argillaceous tuff.
- Tufaceous sandstone with a few leaves and bones.
- Tufaceous sandstone with clay balls containing shells.
- Interbedded ash and clay (main plant layer), a few bones.
- Tufaceous sandstone (main bone layer) (*Pithecanthropus*), a few plants and fresh water-shells.

Lahar conglomerate.

The restricted size of the present island of Java, probably of postglacial origin, proved inimical to some of the larger mammals, for the elephant and tapir are absent in the existing fauna, although a rhinoceros still inhabits the uplands. The recentness of Java's separation from the mainland is shown by the Siamese and Indian character of its

[4] Vertebrate paleontologists differ regarding the distinctness of the majority of these animals from those still existing. The majority of the fossils are certainly very close to modern oriental forms.

present fauna and flora. Of its 90 existing mammals no genera and only 5 or 6 species are peculiar. Of its 300 land birds many are Indo-Chinese and only about 45 are peculiar. The modern flora is also distinctly Malayan or Asiatic in character.

The plants found associated with the ape man are of the greatest interest. They number 54 species and the remarkable fact should be noted that none of these are extinct species, a sure indication of their Pleistocene age. Twenty-two families are represented, the most abundant being the bread fruit banyan or fig family (Moraceæ), the custard apple or pawpaw family (Anonaceæ) and the laurel family (Lauraceæ). There were banyans and figs, jack fruit, mangosteen and custard apple, senna and beans, and a variety of other fruit-bearing trees that may have yielded toll to the Trinil race. The Chinese banyan, a large widely spreading, fast-growing tree, a twig of which is shown in the accompanying sketch (Fig. 3), was present at Trinil at that time. The rasamala

FIG. 3. LEAFY FRUIT BEARING SHOOT OF THE CHINESE BANYAN, *Ficus infectoria* Roxb., found fossil at Trinil. 3/7 nat. size.

(*Altingia excelsa* Noronha) related to our sweet gum was also found at Trinil. To-day it does not occur in the vicinity, although it is one of the tallest and noblest trees of central and western Java, extending thence northwestward to the Asiatic mainland.

The present geographical distribution of these early Pleistocene plants is somewhat different from what it was at the time of the ape man and these differences are a measure of the time that has elapsed since those remote days. Only ten of these plants still flourish in the im-

mediate vicinity of Trinil, where the climate is now drier and somewhat warmer, but 32 of them, or 62 per cent., are still found in Java. Twenty-nine, or 57 per cent., are mainly Indo-Chinese and one (*Uvaria*) is now confined to India and Ceylon. The flora was an evergreen forest flora, upland in character, and is much like that found at the present time in the Khassis Mountains of Assam. It indicates the very heavy rainfall of about 150 inches yearly as compared with 60 to 100 inches of the modern records. A mean annual temperature of about 70° is indicated for the early Pleistocene as compared with 75° to 80° of the present.

The heavy rains and slight lowering of temperatures appear to correspond to the times of glaciation in Europe and North America, for it is well known that glaciation in high latitudes was contemporaneous with pluvial periods in the tropics. The survival of so many mammals like those of the Pliocene of the foothills of the Himalayas indicate that the Trinil man lived in early Pleistocene times, but the fact that none of the numerous associated fossil plants are extinct species and that none are identical with known Pliocene plants from Java and Japan indicate that it must have fallen well within the Pleistocene. That the lower bone bed was not appreciably older than the main plant bed which lies over it is shown by the presence of some of the same species of plants and fresh-water shells in the bone bed and by the presence of some of the bones above the main plant bed. We are thus led to the conclusion that *Pithecanthropus* lived in the tropical evergreen forests of Java during the first or second periods of glaciation in Europe and North America, or during what Europeans call the Scanian (Günz) and Saxonian (Mindel) glaciations, corresponding to our Nebraskan and Kansan ice sheets.

This was a long time ago, just how long it is difficult to say. Penck from very careful estimates based on a detailed study of the glaciers of the Alps estimated that the duration of the Pleistocene was between 520,000 and 840,000 years. Osborn considers that *Pithecanthropus* lived about 500,000 years ago. Personally I believe these estimates to be too large. One fact stands out clearly, that very many thousands of years have passed since the ape man and the elephants and hippopotami roamed over Java. Some realization of this time may be gathered if we deal in the more positive ratios rather than in actual estimates of years. If the time that has elapsed since the margin of the ice sheet blocked our great lakes and covered New England be taken as a unit, then the lapse of time since *Pithecanthropus* was buried in the river sands of Java was at least twenty times as great.

When we look at the admirable restoration of *Pithecanthropus* by McGregor we see many indications of the ape ancestry and yet he has managed to catch a look of fleeting intelligence and a dumb prophetic gaze that gives a promise of the great things that the descendants of

this far-off ape man were to accomplish. Whether this early Pleistocene man, by far the oldest yet known, stood in the direct line of ascent to the Neanderthal man which we find later on in Europe, or whether he represented an offshoot of this line, yet one can not contemplate his few bones that have come down to us or that empty brain case without a tremendous thrill.

The earth had been luxuriant and mild for eons, practically all the modern types of animals and plants had already been evolved and then in the dawning days of the Pleistocene with the coming on of more severe climatic conditions we find the early representatives of our own race, subsequently evolving into nomadic hunters and artistic cave dwellers, that spread all over southern Europe, migrating westward in successive waves from the more arid orient. Races that saw the great glaciers of the Rhone and the Rhine and hunted the wild horses and mastodons in southern France. It is a most inspiring history beside which Nineveh and Tyre are as but yesterday.

THE ORIGIN AND EVOLUTION OF LIFE UPON THE EARTH[52]

By HENRY FAIRFIELD OSBORN

COLUMBIA UNIVERSITY; AMERICAN MUSEUM OF NATURAL HISTORY

Lecture I, Part II

Primordial Environment—Energy Derived from the Sun's Heat and Light—Life Elements in the Solar Spectrum

In the change from the lifeless to the living world the *properties* of the "life elements" become known as *functions.*

The earliest function of living matter appears to have been to capture and transform the electric energy of those chemical elements which throughout we designate as the "life elements." This function appears to have developed only in the presence of heat energy, derived either from the earth or from the sun. This is the first example in the life process of the utilization of energy wherever it may be found. At a later stage of evolution life captured the light energy of the sun through the agency of chlorophyll, the green coloring matter of plants.

If the lifeless surface of the primordial earth was like that of the moon—covered not only with igneous rocks but with piles of heat-storing débris, as recently described by Russell[53]—the reflecting power of the earth's surface represented a loss of 40 per cent. of the sun's heat, as compared with the present reflecting power of the earth which results in a loss of 47 per cent. of the sun's heat; while the solar radiation constant, as measured by Abbott, is 1.923.

The primal dependence of the electric energy of life on the original heat energy of the earth or on solar heat is demonstrated by the universal behavior of the most primitive organisms, because when the temperature of protoplasm is lowered 0° C. the velocity of the chemical reactions becomes so small that in most cases all manifestations of life are suspended, that is, life becomes latent. Some bacteria grow at or very near the freezing point of water (0° C.) and possibly primordial bacteria-like organisms grew below that point. Even now the common "hay bacillus" grows at 6° C.[54] Rising temperatures increase the velocity of the biochemical reactions of protoplasm up to an optimum temperature, beyond which they are increasingly injurious and finally fatal to all organisms. In hot springs some of the Cyanophyceæ (blue-green algæ), primitive plants intermediate in evolution between bacteria

[52] Fourth course of lectures on the William Ellery Hale Foundation, National Academy of Sciences, delivered at the meeting of the academy at Washington, on April 17 and 19, 1916.

[53] Russell, H. N., 1916, p. 75.

[54] Jordan, Edwin O., 1908, pp. 67, 68.

and algæ, sustain temperatures as high as 63° C. and, as a rule, are killed by a temperature of 73° C., which is probably the coagulation point of their proteins. Setchell found bacteria living in water of hot springs at 89° C.[55] In the next higher order of the Chlorophyceæ (green algæ) the temperature fatal to life is lower, being 43° C.[56] Very much higher temperatures are endured by the spores of certain bacilli which survive until temperatures of from 105° C. to 120° C. are reached. There appears to be no known limit to the amount of dry cold which they can withstand.[57]

It is this power of the relatively water-free spores to resist heat and cold which has suggested to Richter (1865), to Kelvin, and to Arrhenius (1908) that living germs may have pervaded space and may have reached our planet either in company with meteorites (Kelvin)[58] or driven by the pressure of light (Arrhenius).[59] The fact that so far as we know life has only originated once and not repeatedly appears to dispose of these hypotheses; nor is it courageous to put off the problem of life origin into cosmic space instead of resolutely seeking it within the forces and elements of our own humble planet.

The thermal conditions of living matter point to the probability that life originated when portions at least of the earth's surface and waters had temperatures of between 89° C. and 6° C.; and also to the possibility of the origin of life before the atmospheric vapors admitted a regular supply of sunlight.

After the sun's heat living matter appears to have captured the sun's light which is essential, directly or indirectly, to all living energy higher than that of the most primitive bacteria. The discovery by Lavoisier (1743–1794) and the development (1804) by de Saussure[60] of the theory of photosynthesis, namely, that sunshine, combining solar heat and light, is a perpetual source of living energy, laid the foundations of biochemistry and opened the way for the establishment of the law of the conservation of energy within the living organism. This was the first conception of the cycle of the elements continually passing through plants and animals which was so grandly formulated by Cuvier in 1817:[61]

[55] *Op. cit.*, p. 68.

[56] Loeb, Jacques, 1906, p. 106.

[57] Cultures of bacteria have even been exposed to the temperature of liquid hydrogen (about —250° C.) without destroying their vitality or sensibly impairing their biologic qualities. This temperature is far below that at which any chemical reaction is known to take place, and is only about 23 degrees above the absolute zero point at which, it is believed, molecular movement ceases. On the other hand, when bacteria are frozen in water during the formation of natural ice the death rate is high. See Jordan, Edwin O., 1908, p. 69.

[58] Poulton, Edward B., 1896, p. 818.

[59] Pirsson, Louis V., and Schuchert, Charles, 1915, pp. 535, 536.

[60] De Saussure, N. T., 1804.

[61] Cuvier, Baron Georges L. C. F. D., 1817, p. 13.

La vie est donc un tourbillon plus ou moins rapide, plus ou moins compliqué, dont la direction est constante, et qui entraîne toujours des molécules de mêmes sortes, mais où les molécules individuelles entrent et d'où elles sortent continuellement, de manière que la *forme* du corps vivant lui est plus essentielle que sa *matière*.

CHEMICAL COMPOSITION OF CHLOROPHYLL

Carbon	73.34
Hydrogen	9.72
Nitrogen	5.68
Oxygen	9.54
Phosphorus	1.38
Magnesium	0.34
	100.00

The green coloring matter of plants is known as chlorophyll; its chemical composition according to Hoppe-Seyler's analysis is given here.[62] Potassium is essential for its assimilating activity. Iron (often accompanied by manganese) although essential to the production of chlorophyll is not contained in it. The chlorophyll-bearing leaves of the plant in the presence of sunlight separate the oxygen atoms from the carbon and hydrogen atoms in the molecules of carbon dioxide (CO_2) and of water (H_2O), storing up the energy of the hydrogen and carbon in the carbohydrate substances of the plant, an energy which is

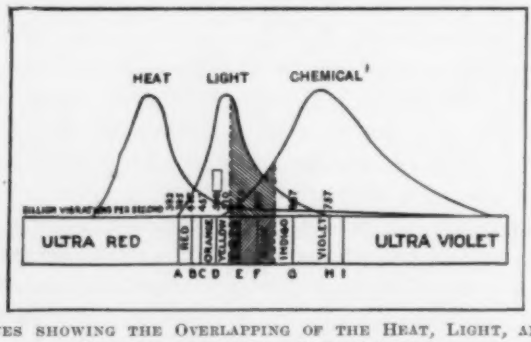


FIG. 1. CURVES SHOWING THE OVERLAPPING OF THE HEAT, LIGHT, AND CHEMICAL WAVES OF THE SUN. After Dahlgren.

stored by deoxidation and which can be released only through reoxidation. Thus the celluloses, sugars, starches, and other similar substances which deposit their kinetic energy in the tissues of the plant, release that energy through the addition of oxygen, the amount of oxygen required being the same as that needed to burn similar substances in the air to the same degree; in brief, a combustion which generates heat.[63] Thus living matter utilizes the energy of the sun to draw a continuous stream of electric energy from the elements in the earth, the water, and the atmosphere.

This was the first step in the interpretation of life processes in the

[62] Sachs, Julius, 1882, p. 758.

[63] W. J. Gies.

terms of physics and chemistry. What was regarded 100 years ago as a special vital force in the life of plants proved to be an adaptation of physico-chemical forces. The chemical action of chlorophyll is not fully understood, but it is known to absorb most vigorously the solar rays between B and C of the spectrum,[64] and these rays are most effective in assimilation. While the effect of the solar rays between D and E is minimal those beyond F are again effective. In heliotropic movements both of plants and animals the blue rays are more effective than the red.[65] Spores given off as ciliated cells from the algæ seek first the blue rays. Since the food supply of animals is primarily derived from chlorophyll-bearing plants animals are less directly dependent on the solar light and solar heat while the chemical life of plants fluctuates throughout the day with the variations of light and temperature. Thus Richards[66] finds in the cacti that the breaking down of the acids through the splitting of the acid compounds is a respiratory process caused by the alternate oxidation and deoxidation of the tissues through the action of the sun.

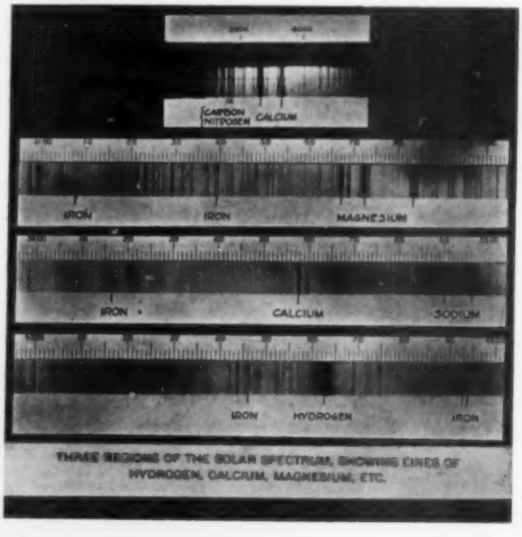


FIG. 2. THREE REGIONS OF THE SOLAR SPECTRUM SHOWING THE LINES OF CARBON, NITROGEN, CALCIUM, IRON, MAGNESIUM, SODIUM AND HYDROGEN. From the the Mt. Wilson Observatory.

The solar energy transformed into the chemical potential energy of the compounds of carbon, hydrogen, and oxygen in the plants is transmuted by the animal into motion and heat and then dissipated. Thus in the life cycle we observe both the conservation and the degradation of

[64] Loeb, Jacques, 1906, p. 115.

[65] *Op. cit.*, p. 127.

[66] Richards, Herbert M., 1915, pp. 34, 73–75.

energy, corresponding with first and second laws of thermodynamics developed in physics by the researches of Newton, Helmholtz, Phillips, Kelvin, and others.[67]

"Life Elements" in the Sun and in our Planet

We have thus observed that the primal earth, air and water contained all the chemical elements and three of the most simple but important chemical compounds, namely, water, nitrates and carbon dioxide, which are known to be essential to the pre-chlorophyllic and chlorophyllic stages of the life process. An initial step in the origin of life was the coordination or bringing together of these elements which, so far as we know, had never been in combined action before and are widely distributed as they appear in the solar spectrum. Therefore, before examining the properties of these elements further, it is interesting to trace them back into the sun and thus into the cosmos.

Excepting hydrogen and oxygen, the principal elements which enter into the formation of protoplasm are minor constituents of the mass of matter sown throughout space in comparison with the rock-forming elements.[68] Again excepting hydrogen, their lines in the solar spectrum are for the most part weak and only shown on high dispersion plates, while hydrogen is represented by very strong lines as shown by spectroheliograms of solar prominences. The lines of oxygen are relatively faint; it appears principally as a compound, titanium oxide (TiO_2), in sunspots although a triple line in the extreme red seems also to be due to it. In the chromosphere, or higher atmosphere of the sun, hydrogen is not in a state of combustion, and the fine hydrogen prominences show radiations comparable to those in a vacuum tube.[69]

Nitrogen, the next most important life element, is displayed in the so-called cyanogen bands of the ultra-violet, made visible by high dispersion photographs. Carbon is shown in many lines in green, which are relatively bright near the sun's edge; it is also present in comets, and carbonaceous meteorites (Orgueil, Kold Bokkeveld, etc.) are well known. Graphite occurs in meteoric irons.

In the solar spectrum so far as studied no lines of the "life elements," phosphorus, sulphur, and chlorine, have been detected. On the other hand, the metallic elements which enter into the life compounds, iron, sodium and calcium, are all represented by strong lines in the solar spectrum, the exception being potassium in which the lines are faint. Of the eight metallic elements which are most abundant in the earth's crust as well as the non-metallic elements carbon and silicon, six are also among the eight strongest in the solar spectrum. In general, however, the important life elements are very widely distributed

[67] Henderson, Lawrence J., 1913, pp. 15–18.

[68] Russell, Henry Norris, letter of March 6, 1916.

[69] Hale, George Ellery, letter of March 10, 1916.

in the stellar universe, showing most prominently in the hotter stars, and in the case of hydrogen being universal.

Action and Reaction as Adaptive Properties of the Life Elements

Of the total of eighty-two or more chemical elements thus far discovered at least twenty-nine are known to occur in living organisms either invariably, frequently, or rarely, as shown in the accompanying Table II of the Life Elements. The adaptation of the life elements is due to their incessant action and reaction, each element having its peculiar and distinctive forms of action and reaction, which in the organism are transmuted into functions. Such activity of the life elements is largely connected with forms of electric energy which the physicists call *ionization,* while the correlated or coordinated *interaction* of various groups of life elements is largely connected with processes which the chemists term *catalysis.* Of catalysis we shall speak later.

Ionization, the actions and reactions of all the elements and electrolytic compounds—according to the hypothesis of Arrhenius, first put forth in 1887—is primarily due to electrolytic dissociation whereby the molecules of all acids (*e. g.,* carbonic acid, H_2CO_3), bases (*e. g.,* sodium hydroxide, NaOH), and salts (*e. g.,* sodium chloride, NaCl) give off streams of the electrically charged particles known as ions. Ionization is dependent on the law of Nernst that the greater the dielectric capacity of the solvent (*e. g.,* water) the more rapid will be the dissociation of the substances dissolved in it, other conditions remaining the same. Thus ions are atoms or groups of atoms carrying electric charges which are positive when given off from metallic elements, and negative when given off from non-metallic elements. Electrolytic molecules, according to this theory, are constantly dissociating to form ions and the ions are as constantly recombining to form molecules. Since the salts of the various mineral elements are constantly being decomposed through electrolytic ionization, they play an important part in all the life phenomena; and since similar decomposition is induced by currents of electricity, indications are that all the development of living energy is in a sense electric.

In Rutherford's experiments on radioactive matter[70] he tells us that in the phosphorescence caused by the approach of an emanation of radium to zinc sulphate the atoms throw off the alpha particles to the number of five billion each second with velocities of 10,000 miles a second; that the alpha particles in their passage through air or other medium produce from the neutral molecules a large number of negatively charged ions, and that this ionization is readily measurable.

Phosphorescence in plants and animals is also regarded by Loeb[71] as

[70] **Rutherford, Sir Ernest, 1915, p. 115.**

[71] **Loeb, Jacques, 1906, pp. 66–68.**

a form of radiant energy. While developed in a number of living animals—including the typical glowworms in which the phenomenon was first investigated by Faraday—the living condition is not essential to it because the phosphorescence continues after death and may be produced in animals by non-living material. Many organisms show phosphorescence at comparatively low temperatures, yet the presence of free oxygen appears to be necessary.

Finally, we observe that ionization is connected with the radioactive elements, of which thus far only radium has been detected in the organic compounds although the others may be present.

The ionizing electric properties of the life elements are a matter of first importance. We observe at once in the table below that all the great structural elements which make up the bulk of plant and animal tissues are of the non-metallic group with negative ions, with the single exception of hydrogen which has positive ions. All these elements are of low atomic weight and several of them develop a great amount of heat in combustion, hydrogen and carbon leading in this function of the

TABLE II

THE LIFE ELEMENTS, SHOWING THEIR PRINCIPAL PROPERTIES AND FUNCTIONS IN PLANTS AND ANIMALS

Mainly or Wholly with or in Negative Ions[72]		Mainly or Wholly with or in Positive Ions[72]		
Non-metallic		Metallic		
[73] **Carbon** (*e. g.*,[75] carbonates)	**Silicon**	[77] **Hydrogen**	[78] **Iron**	**Lithium**
[73] **Oxygen** (*e. g.*,[75] sulphates)	**Iodine**	**Potassium**	**Copper**	**Nickel**
[73] [74] **Nitrogen** (*e. g.*,[75] nitrates)	**Bromine**	**Sodium**	**Aluminum**	**Radium**
[73] **Phosphorus** (*e. g.*,[75] phosphates)	**Fluorine**	**Calcium**	**Barium**	**Strontium**
[73] **Sulphur** (*e. g.*,[75] sulphates)	**Boron**	**Magnesium**	**Cobalt**	**Zinc**
Chlorine	[76] **Arsenic**	**Manganese**	**Lead**	

Ionization Elements thus far Discovered in Living Organisms

72 An ion is an atom or group of atoms carrying an electric charge. The positive ions (cations) of the metallic elements move toward the cathode: the negative ions (anions) given off by the non-metallic elements move toward the anode.

73 Together with hydrogen conspicuous in living colloids and non-electrolytes —very little in the indicated ionized forms.

74 Occurs also, as NH_4, in *positive* ions. Here the hydrogen overbalances the nitrogen.

75 Substances occurring in living matter.

76 Arsenic itself is a metal, but in living compounds it is an analogue of phosphorus and occurs in *negative* ions when ionized.

77 Pictet has obtained results indicating that liquid and solid hydrogen are metallic. Hydrogen is metallic in *behavior,* though non-metallic in *appearance.*

78 Iron in living compounds is chiefly non-ionized, colloidal. Apparently this is also true of copper, aluminum, barium, cobalt, lead, nickel, strontium and zinc. As to radium, however, there is no information on this point.

Elements Invariably Present in Living Organisms[79]

Atomic Weight	Heat Combustion per Gram	Element	Symbol	Plants	Animals
1.008	34.702 cal. (H_2)	*Hydrogen*	H	Hydrogen, carbon, oxygen, and nitrogen—"C, O, H, esses; forming, with sulphur, practically all plant ing the nucleoproteins.	N"—are *essential and of chief rank* in all life proc- and animal proteins, and, with phosphorus, form-
12.005	8.08 "	*Carbon*	C		
16.00		*Oxygen*	O		
14.01	0.143 "	*Nitrogen*	N		
31.04	5.747 "	*Phosphorus*	P	In nucleoproteins and phospholipins.	In nucleoproteins and phospholipins; in some brachiopods; in blood; and in vertebrate bone and teeth.
32.06	2.22 "	*Sulphur*	S	In most proteins, 0.1–5.0 per cent.	In most proteins, 0.1–5.0 per cent.
39.16	1.745 "	*Potassium*	K	Abundant in marine plants, esp. "kelps" (larger *Phæophyceæ*); activity of chlorophyll depends on it.	In blood, muscle, etc.
24.32	6.077 "	*Magnesium*	Mg	Present in large quantities in *Corallinaceæ* (a family of calcified red algæ).	Present in echinoderms and alcyonarians;[80] present in all parts of vertebrates, esp. in bones.
40.07	3.284 "	*Calcium*	Ca	Present in large quantities in certain algæ (chiefly marine).	In all parts of vertebrates; abundant in bones and teeth
55.84	1.353 "	*Iron*	Fe	Essential in the formation of protoplasm.	Essential in the formation of protoplasm, and in the higher animals; essential in hemoglobin as an oxygen carrier.
23.00	3.293 "	?*Sodium*	Na	Believed essential to all plants, but not demonstrated; found in marine plants, esp. *Phæophyceæ*.	Present in all animals; abundant in blood and lymph.
35.46	0.254 "	?*Chlorine*	Cl	Present in many plants; believed by some to be essential; abundant in marine algæ, esp. in the *Phæophyceæ*.	Present in all animals; abundant in blood and lymph; present in the gastric juice.
28.3		?*Silicon*	Si	Found in all plants; present in large quantities in the *Diatomaceæ*, both fresh-water and marine; in form of "silica" constitutes 0.5–7.0 per cent. of the ash of ordinary marine algæ.	Present in radiolarians and siliceous sponges; also in all the higher animals.

[79] Observe that the most active elements in organic compounds generally have low atomic weights; and that the most active element, hydrogen, has the highest combustion heat in calories per gram.

[80] Magnesium is also found in many other invertebrates than those mentioned.

Elements Frequently Present in Living Organisms

Atomic Weight	Heat Combustion per Gram	Element	Symbol	Plants	Animals
126.92	0.1766 cal.	*Iodine*	I	In marine plants, esp. the "brown algæ," *Phæophyceæ;* in *Laminaria* and *Fucus;* also in some Gorgonias.	Essential in the higher animals (thyroid).
54.93		*Manganese*	Mn	In some plants.	In most animals in very slight proportions.
79.92		*Bromine*	Br	In marine plants, esp. the "brown algæ," *Phæophyceæ;* in some Gorgonias.	In some animals in very slight proportions.
19.0		*Fluorine*	F	In a few plants.	In some animals—constituent of bones and teeth; in shells of molluscs and in vertebrate bones.

Elements Rarely Present in Living Organisms

Atomic Weight	Heat Combustion per Gram	Element	Symbol	Plants	Animals
27.1		[81]*Aluminum*	Al	In a few plants.	In a few animals.
74.96	1.463 cal.	[81]*Arsenic*	As		In some animals.
137.37	0.952 "	[81]*Barium*	Ba	In a few plants.	
11.0		*Boron*	B	In some plants.	
58.97		[81]*Cobalt*	Co	In a few plants.	
63.57	0.585 "	[81]*Copper*	Cu	In a few plants.	Traces in some corals; essential in some lower animals as oxygen carrier.
207.20	0.243 "	[81]*Lead*	Pb		Traces in some corals.
6.94		*Lithium*	Li	In some plants.	
58.08		[81]*Nickel*	Ni	In a few plants.	
226.0		[81]*Radium*	Ra	In some plants.	In some animals.
87.63	1.497 "	[81]*Strontium*	Sr	In a few plants.	
65.37	1.291 "	[81]*Zinc* !	Zn	In a few plants.	In a few animals; traces in some corals.

The exceedingly rare occurrence of cerium, chromium, didymium, lanthanum, molybdenum, silver and vanadium is in all probability merely adventitious.

[81] Commonly regarded as poisons when present in *mineral* (ionic) forms, even in small proportions.

release of energy, which invariably takes place in the presence of oxygen. On the other hand, the lesser components of organic compounds are the metallic elements with positive ions, such as potassium, sodium, calcium, and magnesium, calcium combining with carbon or with phosphorus as the great structural or skeletal builder in animals. There is also so much carbonaceous protein in the animal skeleton that in animals calcium takes the place of carbon in plants only in the sense that it reduces the *proportion* of carbon in the skeleton: it shares the honors with carbon.

In general the electric action and reaction of the non-metallic and the metallic elements dissolved or suspended in water is believed to be the source of all the internal functions of life, which are developed always in the presence of oxygen and with the energy either of the heat of the earth, or of the sun, or of both the heat and light of the sun.

Cosmic Properties and Life Functions of the Chief Life Elements

Both the time and the mode of the origin of life is a matter of pure speculation, in which we have as yet no observation or uniformitarian reasoning to guide us, for all the experiments of Bütschli and others to imitate the original life process have proved fruitless. We may, however, put forward four hypotheses in regard to it, as follows:

First: we may advance the hypothesis that an early step in the organization of living matter was the assemblage one by one of several of the ten elements essential to life, namely, hydrogen, oxygen, nitrogen, phosphorus, sulphur, potassium, calcium, magnesium, iron (also perhaps silicon), and carbon, which are present in all living organisms with the exception of some of the most primitive forms of bacteria, which may lack carbon, magnesium, iron and silica. Of these the four most important elements were obtained from their previous combination in water (H_2O), from the nitrogen compounds of volcanic emanations or from the atmosphere,[82] consisting largely of nitrogen and from atmospheric carbon dioxide (CO_2). The remaining six elements, phosphorus, sulphur, potassium, calcium, magnesium and iron, came from the earth.

Second: whether there was a sudden or a more or less serial grouping of these elements, one by one, we are led to a second hypothesis that they were gradually bound by a new form of mutual attraction whereby the actions and reactions of a group of life elements established a new form of unity in the cosmos, an organic unity or *organism* quite distinct from the larger and smaller aggregations of inorganic matter previously held or brought together by the forces of gravity. Some such stage of

[82] Ammonia is also formed by electrical action in the atmosphere and unites with the nitric oxides to form ammonium nitrate or nitrite: these compounds fall to earth in rain.—F. W. Clarke.

mutual attraction may have been ancestral to the cell, the primordial unity and individuality of which we shall describe later.

Third: this leads to the hypothesis that this grouping occurred in the gelatinous state described as "colloidal" by Graham.[83] Since all living cells are colloidal it appears probable that this grouping of the "life elements" took place in a state of colloidal suspension, for it is in this state that the life elements best display their incessant action, reaction and interaction. Bechhold[84] observes that

> Whatever the arrangement of matter in living organisms in other worlds may be, it must be of colloidal nature. What other condition except the colloidal could develop such changeable and plastic forms, and yet be able, if necessary, to preserve these forms unaltered?

Fourth: with this assemblage, mutual attraction, and colloidal condition, a fourth hypothesis is that there arose the rudiments of competition and selection. Was there any stage in this grouping, assemblage, and organization of life forms, however remote or rudimentary, when the law of natural selection did not operate between different unit aggregations of matter? Probably not, because *each of the chemical life elements possesses its peculiar properties which in living compounds best serve certain functions.* This cooperation was also an application of energy new to the cosmos. In other words, every element, as shown

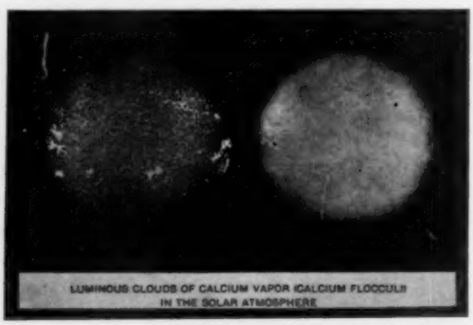


FIG. 3. TWO PHOTOGRAPHS OF THE SUN SHOWING (LEFT) THE CLOUDS OF CALCIUM VAPOR IN THE SOLAR ATMOSPHERE, AND (RIGHT) GROUPS OF SUN SPOTS. From the Mt. Wilson Observatory.

in Table II., "The Life Elements" (pp. 176–178), and in the descriptions below, has its single or multiple services to render to the organism.

Hydrogen, the life element of least atomic weight, is always near the surface of the typical hot stars. Rutherford[85] tells us that while the hydrogen atom is the lightest known its negatively charged electrons

[83] Over fifty years ago Thomas Graham introduced the term "colloid" (L. *colla,* glue) to denote coagulating substances like gelatine, a typical colloid, as distinguished from crystalloids. Proteins belong to that class of colloids which, once coagulated, can not return to the liquid condition.

[84] Bechhold, Heinrich, 1912, p. 194.

[85] Rutherford, Sir Ernest, 1915, p. 113.

are only about 1/1800 of the mass of the hydrogen atom: they are liberated from metals on which ultra-violet light falls, and can be released from atoms of matter by a variety of agencies. Hydrogen is present in all acids and in most organic compounds. It also has the highest power of combustion.[86] Its ions are very important factors in animal respiration and in gastric digestion.[87] It is very active in dissociating or separating oxygen from various compounds, and through its affinity for oxygen forms water (H_2O), the principal constituent of protoplasm.

Oxygen, like hydrogen, has an attractive power which brings into the organism other elements useful in its various functions. It makes up two thirds of all animal tissue as it makes up one half of the earth's crust. Beside these attractive and synthetic functions its great service is as an oxidizer in the release of energy; it is thus always circulating in the tissues. Through this it is involved in all heat production and in all mechanical work, and affects cell division and growth.[88]

Nitrogen comes next in importance to hydrogen and oxygen as structural material[89] and when combined with carbon and sulphur gives the plant and animal world one of the chief organic food constituents, protein. It was present on the primordial earth, not only in the atmosphere but also in the gases and waters emitted by volcanoes. Combined with hydrogen it forms various radicles of a basic character (*e. g.*, NH_2 in amino acids, NH_4 in ammonium compounds); combined with oxygen it yields acidic radicles such as NO_3 in nitrates. It combines with carbon in $-C\equiv N$ radicles and in $\equiv C-NH_2$ and $=C=NH$ forms, the latter being particularly important in protoplasmic chemistry.[90] This life element forms the basis of all explosives, it also confers the necessary instability upon the molecules of protoplasm because it is loath to combine with and easy to dissociate from most other elements. Thus we find nitrogen playing an important part in the physiology of the most primitive organisms known, the nitrifying bacteria.

Carbon also exists at or near the surface of cooling stars which are becoming red.[91] It unites vigorously with oxygen, tearing it away from neighboring elements, while its tendency to unite with hydrogen is less marked. At lower heats the carbon compounds are remarkably stable, but they are by no means able to resist great heats; thus Barrell[92] observes that a chemist would immediately put his finger on the element carbon as that which is needed to endow organic substance with complexity of form and function, and its selection in the origin of plant life

[86] Henderson, Lawrence J., 1913, pp. 218, 239, 245.
[87] Gies, W. J.
[88] Loeb, Jacques, 1906, p. 16.
[89] Henderson, Lawrence J., 1913, p. 241.
[90] Gies, W. J.
[91] Henderson, Lawrence J., 1913, p. 55.
[92] Barrell, Joseph, letter of March 20, 1916.

was by no means fortuitous. Including the artificial products the known carbon compounds exceed 100,000, while there are thousands of compounds of C, H, and O, and hundreds of C and H.[93] Carbon is so dominant in living matter that biochemistry is very largely the chemistry of carbon compounds; and it is interesting to observe that in the evolution of life each of these biological compounds must have arisen suddenly as a saltation or mutation, there being no continuity between one chemical compound and another.

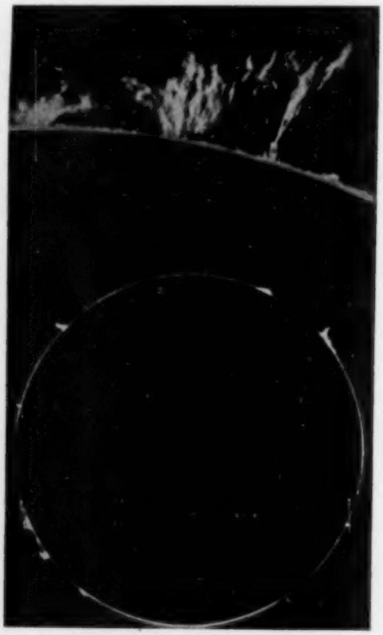


FIG. 4. (LOWER) SOLAR PROMINENCES SURROUNDING THE SUN. (UPPER) THE SAME GREATLY ENLARGED. From Mt. Wilson Observatory.

Phosphorus is essential in the nucleus of the cell,[94] being a large constituent of the intranuclear germ plasm, or chromatin, which is the seat of heredity. It enters largely into the structure of nerves and brain, and also, as phosphates of calcium and magnesium, serves an entirely diverse function as building material for the skeletons of animals.

Sulphur, uniting with nitrogen, oxygen, hydrogen and carbon, is an essential constituent of the proteins of plants and animals.[95] It is especially conspicuous in the epidermal protein known as keratin, which by its insolubility mechanically protects the underlying tissues.[96] Sulphur

[93] Henderson, Lawrence J., 1913, p. 193.

[94] *Op. cit.*, p. 241.

[95] *Op. cit.*, p. 242.

[96] Pirsson, Louis V., and Schuchert, Charles, 1915, p. 434.

is also contained in one of the physiologically important substances of bile.[97]

Potassium separates hydrogen from its union with oxygen in water, and is the most active of the metals, biologically considered, in its positive ionization.[98] Through stimulation and inhibition potassium salts play an important part in the regulation of life phenomena, and they are essential to the living tissues of plants and animals, fresh-water and

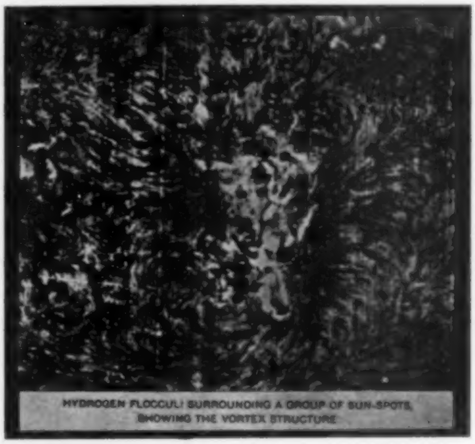


FIG. 5. HYDROGEN FLOCCULI SURROUNDING A GROUP OF SUN SPOTS SHOWING THE VORTEX STRUCTURE. From the Mt. Wilson Observatory.

marine plants, in particular, storing up large quantities in their tissues.[99] Potassium is of service to life in building up complex compounds from which the potassium can not be dissociated as a free ion; it is thus one of the building stones of living matter.[100]

Magnesium is fourth in order of activity among the metallic elements. It is essential to the chlorophyll, or green coloring matter of plants, which in the presence of sunshine serves in the dissociation of oxygen from the carbon of carbon dioxide and the hydrogen of water. It is also found in the skeletons of many invertebrates and in the coralline algæ.

Calcium is third in order of activity among the metallic elements. According to Loeb[101] it plays an important part in the life phenomena through stimulation (irritability) and inhibition. It unites with carbon as carbonate of lime and is contained in many of those animal skeletons which, through deposition, make up an important part of the earth's crust. In invertebrates the carbonate, except in certain brachiopods, is

[97] Gies, W. J.
[98] Caesium is more electropositive.—F. W. Clarke.
[99] Loeb, Jacques, 1906, p. 94.
[100] *Op. cit.*, p. 72.
[101] *Op. cit.*, 1906, p. 94.

far more important as skeletal material than the phosphates: the limestones form only about five per cent. of the sedimentaries. Shales and sandstones are far more abundant.

Iron is essential for the production of chlorophyll[102] though, unlike magnesium, it is not contained in it. It is present as well in all protoplasm, while in the higher animals it serves, in the form of oxyhemoglobin, as a carrier of oxygen from the lungs to the tissues.[103]

Sodium is less important in the nutrition of plant tissues, but serves an essential function in all animal life in relation to movement through muscular contraction.[104] Its salts, like those of calcium, play an important part in the regulation of life phenomena through stimulation and inhibition.[105]

Iodine, with its negative ionization, becomes useful through its capacity to unite with hydrogen in the functioning of the brown algæ and in many other marine organisms. It is also an organic constituent in the thyroid gland of the vertebrates.[106] The iodine content of crinoids—stalked echinoderms—varies widely in organisms gathered from different parts of the ocean according to the temperature and the iodine content of the sea-water. Iodine and bromine are important constituents of the organic axes of gorgonias.

Chlorine, like iodine, a non-metallic element with negative ions, is abundant in marine algæ and present in many other plants, while in animals it is present in both blood and lymph. In union with hydrogen as hydrochloric acid it serves a very important function in the gastric digestion of proteins.[107]

Barium, rarely present in plants, has been used in animal experimentation by Loeb, who has shown that its salts induce muscular peristalsis and accelerate the secretory action of the kidneys.[108]

Copper ranks first in electric conductivity. In the invertebrates, in the form of hemocyanine, it acts as an oxygen carrier in the fluid circulation to the tissues.[109] It is always present in certain molluscs, such as the oyster, and also in the plumage of a bird, the Turaco. Although among the rare life elements it ranks first in toxic action upon fungi, algæ, and in general upon all plants, yet it is occasionally found in the tissues of trees growing in copper-ore regions.[110]

In general most of the metallic compounds and several of the non-metallic compounds are toxic or destructive to life when present in large

102 Sachs, Julius, 1882, p. 699.
103 Henderson, Lawrence J., 1913, p. 241.
104 Loeb, Jacques, 1906, p. 79.
105 *Op. cit.*, pp. 94, 95.
106 Henderson, Lawrence J., 1913, p. 242.
107 *Op. cit.*, p. 242.
108 Loeb, Jacques, 1906, p. 93.
109 Henderson, Lawrence J., 1913, p. 241.
110 Howe, M. A., letter of February 24, 1916.

quantities. All the mineral elements of high atomic weight are toxic in comparatively minute proportions, while the essential life elements of low atomic weight are toxic only in comparatively large proportions. Toxicity depends largely upon the liberation of ions, and non-ionized and non-ionizable organic compounds—such as hemoglobin containing non-ionizable iron—are wholly non-toxic.

We thus return to the conception set forth above in our four hypotheses that in the origin and early evolution of the life-organism the gradual selection and grouping of the ten chief life elements and of the nineteen or more subsequently added may have been analogous to a series of inventions and discoveries or to the successive addition of new characters and functions such as we may trace through paleontology in the origin and development of the higher plants and animals.

Prior to the entrance into the organism of the active metals there may have arisen the utilization of the binary compounds of carbon and oxygen (CO_2) and of hydrogen and oxygen (H_2O), to the attractive power of which Henderson[111] has especially drawn our attention. He points out that it is the attraction of oxygen or of hydrogen or of both combined which is now bringing and in the past may have brought into the organism other elements useful to it in its various functions. In other words, oxygen and hydrogen were *selective* agents. In fact, those inorganic compounds which contain neither hydrogen, carbon, nor oxygen make up but a very small percentage of the substance of known bodies. Further, the most active inorganic compounds contain either hydrogen or oxygen. All acids contain hydrogen, most of them oxygen as well, and many bases contain oxygen, although such bases as ammonium (NH_4) do not. Thus hydrogen and oxygen are elements unrivaled in chemical activity, which enable living organisms to make use of other elements at need.

The incorporation of the active metals, potassium, sodium, calcium, magnesium, iron, manganese and copper, into the substance of living organisms may have occurred in the order of their activity in capturing energy from the environment and storing it within the organism. For example, an immense period of time may have been traversed before there occurred the addition of magnesium and iron to certain hydrocarbons which enabled the plant to draw upon the energy of solar light.

Adaptation in the Colloidal State

In the lifeless world matter occurred both in the crystalloidal and colloidal states. It is in the latter state, as observed above (p. 180), that life originated. It is a state peculiarly favorable to action, reaction, and interaction, or the free interchange of physico-chemical energies. Each organism is in a sense a container full of a watery solution in which

[111] Henderson, Lawrence J., 1913, pp. 239, 240.

various kinds of colloids are suspended.[112] Such a suspension involves a play of the energies of the free particles of matter in the most delicate equilibrium, and the suspended particles exhibit the vibrating movement attributed to the impact of the molecules.[113] These free particles are of greater magnitude than the individual molecules, in fact, they represent molecules and multimolecules; and all the known properties of the compounds known as "colloids" can be traced to feeble molecular affinities between the molecules themselves, causing them to unite and to separate in multimolecules. Among the existing living colloids are certain carbohydrates, like starch or glycogen, proteins (compounds of carbon, hydrogen, oxygen and nitrogen with sulphur or phosphorus), and the higher fats. The colloids of protoplasm are dependent for their stability on the constancy of acidity and alkalinity, which is more or less regulated by the presence of bicarbonates.[114]

Electrical charges in the colloids[115] are demonstrated by currents of electricity sent through a colloidal solution, and are interpreted by Freundlich as due to electrolytic dissociation of the colloidal particles, alkaline colloids being positively charged while acid colloids are negatively charged. The concentration of hydrogen and hydroxyl ions in the ocean and in the organism is automatically regulated by carbonic acid (CO_2).[116]

Among the colloidal substances in living organisms the so-called enzymes are very important since they are responsible for many of the processes in the organism. Possibly enzymes are not typical colloids and perhaps, in pure form, they may not be classified as such; but if they are not colloids they certainly behave like colloids.[117]

Coordination of the Properties of the Life Elements through Interaction

We have thus far traced the actions and reactions of the life elements, which are mainly contemporaneous, direct, and immediate; they do not suffice to form an organism. As soon as the grouping of chemical elements reaches the stage of an organism interaction becomes essential, for the chemical activities of one region of the organism must be harmonized with those of all other regions; the principle of interaction may apply at a distance and the results may not be contemporaneous. This is actually inferred to be the case in single-celled organisms such as the *Amœba*.[118]

The interacting and coordinating form of lifeless energy which has

112 Bechhold, Heinrich, 1912.
113 Smith, Alexander, 1914, p. 305.
114 Henderson, Lawrence J., 1913, pp. 157–160.
115 Loeb, Jacques, 1906, pp. 34, 35.
116 Henderson, Lawrence J., 1913, p. 257.
117 Hedin, Sven G., 1914, pp. 164, 173.
118 Calkins, Gary N., 1916, pp. 259, 260.

proved to be of the utmost importance in the life processes in that recognized in the early part of the nineteenth century and denoted by the term catalysis, first applied by Berzelius in 1835. A catalyzer is a substance which modifies the velocity of a distant chemical reaction without itself being used up by the reaction. Thus chemical reactions may be accelerated or retarded and yet the catalyzer loses none of its energy. In a few cases it has been definitely ascertained that the catalytic agent does itself experience a series of changes. The theory is that catalytic phenomena depend upon the alternate decomposition and recomposition, or the alternate attachment and detachment of the catalytic agent.

Discovered as a property in the inorganic world catalysis has proved to underlie the great series of functions in the organic world which may be comprised in the physical term *interaction*. The researches of Ehrlich and others fully justify Huxley's prediction of 1881 that through therapeutics it would become possible "to introduce into the economy a molecular mechanism which, like a cunningly contrived torpedo, shall find its way to some particular group of living elements and cause an explosion among them, leaving the rest untouched." In fact, the interacting agents known as "enzymes" are such living catalyzers[119] which accelerate or retard reactions in the body by forming intermediary unstable compounds which are rapidly decomposed, leaving the catalyzer (*i. e.*, enzyme) free to repeat the action. Thus a small quantity of an enzyme can decompose indefinite quantities of a compound. The activity of enzymes is rather in the nature of the "interaction" of Newton than of direct action and reaction, because the results are produced at a distance and the energy liberated may be entirely out of proportion to the internal energy of the catalyzer. The enzymes being themselves complex organic compounds act specifically because they do not affect alike the different organic compounds which they encounter in the fluid circulation.

Hence, as a fifth hypothesis relating to the origin of organisms, we may advance the idea that the evolution and specialization of various catalyzers (including enzymes or "unformed ferments") has proceeded step by step with the evolution of plant and animal functions. In the evolution from the single-celled to the many-celled forms of life and the multiplication of these cells into hundreds of millions, into billions, and into trillions, as in the larger plants and animals, biochemical coordination and correlation become increasingly essential. In fact, none of the discoveries we have hitherto described throws greater illumination on the life processes than this connected with the internal secretions and the by-products of metabolism in the circulation of the plant and animal fluids. It is known that, as Huxley prophesied, enzymes do reach particular groups of living elements and leave others untouched. For example, the enzyme developed in the yeast ferment produces a different

[119] Loeb, Jacques, 1906, pp. 26, 28.

result in each one of a series of closely related carbohydrates.[120] Driesch[121] has suggested that within the nucleus of the cell is a storehouse of these ferments which pass out into the protoplasm tissues and there set up specific activities; and recently it has been suggested that it is hormones which affect certain hereditary determiners in the chromatin or germ plasm itself.

In 1849 there was given the first experimental proof of action exercised upon an organism by a ductless gland.[124] Berthold transplanted the testicles of young cocks, which afterward developed the masculine voice, sexual desire, comb, and love of combat, thus anticipating Brown-Sequard, who committed himself to the view that a gland, ductless or not, elaborated substances essential to the growth and maintenance of the body. Continuing the investigation of the *chemical correlation of the activities of animal bodies,* Bayliss and Starling proposed the name "hormones" (ὁρμάω, to awaken, stir up). Hormone-producing agents develop from certain *endocrine* organs or glands of internal secretion. The secretion of a gland may act indirectly: *e. g.,* the influence of the thyroid by way of the thymus upon the activities of the stomach.

The heredity theory proposed by Cunningham[122] was based upon the discovery that the connection between the germ cells and the secondary sexual organs, which was supposed to be of a nervous nature, is really chemical. Since hormones from the germ cells determine the development of many other bodily organs, it is possible that hormones due to various cellular activities in the body may act upon the determiners in the germ cells which correspond to the tissues from which these hormones are derived. Cunningham's hypothesis suggests a means by which bodily modifications due to environmental and developmental conditions could modify corresponding determiners in the germ cells.

Catalytic action originates in the by-products of single chemical combinations. For example, the carbon dioxide liberated in cell metabolism acts at a distance on other portions of the cell and of the organism. "In a sense, too," observes Abel, "as has been frequently pointed out, every cell of the body furnishes in the carbon dioxide which it eliminates a hormone or product of internal secretion, since under normal conditions the carbon dioxide of the blood is one of the chief regulators of the respiratory center, influencing this center by virtue of its acidic properties."[123] But in the course of evolution certain entire cells and finally groups of cells took on this function of coordinating and correlating the activity of the complex organism. Thus certain glands arose.

Among the catalysers are those which accelerate general growth through stimulating specific chemical activities and others which retard

[120] Moore, F. J., 1915, p. 170; and Loeb, Jacques, 1906, pp. 21, 22.

[121] Wilson, Edmund B., 1906, p. 427.

[122] Cunningham, J. T., 1908, pp. 372–428.

[123] Abel, John J., 1915, p. 168.

[124] Halsted, William Stewart, 1914, pp. 224, 225.

general growth. There are also catalysers which accelerate or retard the growth of certain organs or parts of the body. The enzyme theory has developed with extreme rapidity but is still, doubtless, in its infancy.

In the concluding section of this lecture we shall trace these physical and chemical principles into some of the simpler forms of life.[125]

(*To be continued*)

List of Works Cited

Abel, John J., 1915. Experimental and Chemical Studies of the Blood with an Appeal for More Extended Chemical Training for the Biological and Medical Investigator. *Science*, August 6, 1915, pp. 165–178.

Bechhold, Heinrich, 1912. Die Kolloide in Biologie und Medizin. Dresden, 1912.

Becker, George F., 1910. The Age of the Earth. Smithsonian Misc. Colls. Washington, 1910.

——1915. Isostasy and Radioactivity. *Bull. Geol. Soc. America*, March, 1915, pp. 171–204.

Calkins, Gary N., 1916. General Biology of the Protozoan Life Cycle. *Amer. Naturalist*, May, 1916, pp. 257–270.

Campbell, William Wallace, 1915. The Evolution of the Stars and the Formation of the Earth. Second series of lectures on the William Ellery Hale foundation, delivered Dec. 7 and 8, 1914. *Pop. Sci. Mon.*, Sept., 1915, pp. 209–235; Scientific Monthly, Oct., 1915, pp. 1–17; Nov., 1915, pp. 177–194; Dec., 1915, pp. 238–255.

Chamberlin, Thomas Chrowder, 1916. The Evolution of the Earth. Third series of lectures on the William Ellery Hale foundation, delivered April 19–21, 1915. Scientific Monthly, May, 1916, pp. 417–437; June, 1916, pp. 536–556.

Clarke, Frank Wigglesworth, 1873. Evolution and the Spectroscope. *Pop. Sci. Mon.*, Jan., 1873, pp. 320–326.

——1916. The Data of Geochemistry. Third edition. Washington, 1916.

Cunningham, J. T., 1908. The Heredity of Secondary Sexual Characters in Relation to Hormones, a Theory of the Heredity of Somatogenic Characters. *Archiv für Entwicklungsmechanik*, Nov. 24, 1907, pp. 372–428.

Cuvier, Baron Georges L. C. F. D., 1817. Le Règne animal distribué d'après son Organisation. Tome I., contenant l'introduction, les mammifères et les oiseaux. Paris, 1817.

——1825. Discours sur les révolutions de la surface du globe et sur les changemens qu'elles ont produit dans le règne animal. See, Recherches sur les Ossemens fossiles. Third edition, Paris, 1825, pp. 1–167.

Darwin, Charles, 1859. On the Origin of Species, by Means of Natural Selection; or the Preservation of Favored Races in the Struggle for Life. London, 1859.

Davies, G. R., 1916. Plato's Philosophy of Education. *School and Society*, April 22, 1916, pp. 582–585.

Eucken, Rudolf, 1912. Main Currents of Modern Thought. Transl. by Booth, New York, 1912.

Halsted, William Stewart, 1915. The Significance of the Thymus Gland in

125 In addition to the acknowledgments made in the introduction, I especially desire to express my indebtedness to Henry Norris Russell, of Princeton University, to George Ellery Hale, of the Mount Wilson Observatory, to Joseph Barrell and Charles Schuchert, of Yale University, who have kindly cooperated through correspondence and otherwise.

Graves's Disease, delivered March 14, 1914. See, The Harvey Lectures, 1913–1914, Phila., 1915, pp. 224–255.

Hedin, Swen G., 1915. Colloidal Reactions and Their Relations to Biology, delivered Jan. 24, 1914. See, The Harvey Lectures, 1913–1914, Phila., 1915, pp. 162–173.

Henderson, Lawrence J., 1913. The Fitness of the Environment. New York, 1913.

Hutton, James, 1795. Theory of the Earth with Proofs and Illustrations. Edinburgh, 1795.

Jordan, Edwin O., 1908. A Text-book of General Bacteriology. Phila. and London, 1908.

Judd, John W., 1910. The Coming of Evolution, The Story of a Great Revolution in Science. Cambridge Manuals of Science and Literature. Cambridge, 1910.

Loeb, Jacques, 1906. The Dynamics of Living Matter. New York, 1906.

Lyell, Charles, 1830. Principles of Geology. London, 1830.

Moore, F. J., 1915. Outlines of Organic Chemistry. New York and London, 1915.

Moulton, F. R., 1912. Description Astronomy. Chicago, 1912.

Osborn, Henry Fairfield, 1894. From the Greeks to Darwin. New York, 1894.

——1908. The Four Inseparable Factors of Evolution. Theory of their Distinct and Combined Action in the Transformation of the Titanotheres, an Extinct Family of Hoofed Animals in the Order Perissodactyla, *Science*, Jan. 24, 1908, pp. 148–150.

——1912, 1. The Continuous Origin of Certain Unit Characters as Observed by a Paleontologist. *Harvey Soc. Volume*, Nov., 1912, pp. 153–204.

——1912, 2. Tetraplasy, the Law of the Four Inseparable Factors of Evolution. *Jour. Acad. Nat. Sci. Phila.* Special volume. Published in Commemoration of the One Hundredth Anniversary of the Founding of the Academy, March 21, 1912. Issued Sept. 14, 1912, pp. 275–309.

Pirsson, Louis V., and Schuchert, Charles, 1915. A Text-book of Geology. Part I., Physical Geology, by Louis V. Pirsson. Part II., Historical Geology, by Charles Schuchert. New York and London, 1915.

Poulton, Edward B., 1896. A Naturalist's Contribution to the Discussion upon the Age of the Earth. Pres. Addr. Zool. Sec. Brit. Ass. delivered Sept. 17, 1896. *Report Brit. Ass. Liverpool*, 1896, pp. 808–828.

Richards, Herbert M., 1915. Acidity and Gas Interchange in Cacti. Washington, 1915.

Russell, H. N., 1916. On the Albedo of the Planets and their Satellites. *Proc. Nat. Acad. Sci.*, 1916, pp. 74–77.

Rutherford, Sir Ernest, 1906. Radioactive Transformations. New York, 1906.

——1915. The Constitution of Matter and the Evolution of the Elements. First series of lectures on the William Ellery Hale foundation, delivered April, 1914. *Pop. Sci. Mon.*, August, 1915, pp. 105–142.

Sachs, Julius, 1882. A Text-book of Botany, Morphological and Physiological. Oxford, 1882.

de Saussure, N. T., 1804. Recherches chimiques sur la Vegetation. Paris, 1804.

Schuchert, Charles (with Pirsson, Louis V.), 1915. A Text-book of Geology. See Pirsson.

Smith, Alexander, 1914. A Text-book of Elementary Chemistry, New York, 1914.

Walcott, Charles D., 1893. Geologic Time, as indicated by the sedimentary rocks of North America. *Jour. Geol.*, Oct.–Nov., 1893, pp. 639–676.

Wilson, Edmund B., 1906. The Cell in Development and Inheritance. Second edition. New York, 1906.

THE RÔLE OF SERVICE IN EVOLUTION

BY PROFESSOR HERVEY WOODBURN SHIMER
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

SERVICE is an essential of life upon this earth. Compulsory it surely is in the vast majority of plants and animals, but it becomes more and more voluntary in the higher types of the invertebrate animals and finds finally its highest expression among the vertebrates in man.

When one organism is forced to yield its body for the nourishment of another it renders the grossest form of compulsory service. Yet all animals and many vegetable forms are dependent upon the death of other organisms for the prolongation of their own life.

"Life evermore is fed by death,
In earth and sea and sky;
And, that a rose may breathe its breath,
Something must die.

"The milk-haired heifer's life must pass
That it may fill your own,
As passed the sweet life of the grass
She fed upon."

To this compulsory service is due nearly all life upon earth and all opportunity for higher development. So that mere living rolls up the debt each individual owes to myriads of other individuals.

A higher type of compulsory service is seen in those organisms in which the production of young results in the death of the parent. This is the case in most herbs among plants and in many protozoöns and insects among animals. Though the organism is compelled to perform this service, it lives its allotted span and then dies; death is not a tragedy. Compulsory service is also rendered by the individuals of one generation to those of the next in the furnishing of food for the developing embryo; the storage of nutriment around the germ in all higher plants, the provision of yolk for consumption within the shell or other envelope in the higher invertebrates and in all vertebrates, except the mammals, as well as the interuterine nourishment of embryonic mammals.

In the instinct, however, which furnishes food and protection to the growing offspring we have, coupled with an involuntary service, a certain amount of the voluntary indicated by variability among individuals of the same species in the amount and kind of labor they expend upon their young. This variability, increasing in the higher types of animals,

is an indication that some individuals are beginning to put a small amount of choice into this service. In the solitary wasps, typified by Ammophila, individuals of the same species differ greatly in the amount of food they furnish their young. Some are good providers, others poor. Some also are exact and precise in all their movements, others are very negligent and disorderly, leaving their offspring less effectively protected in numerous ways.

There is similarly a high degree of difference among individuals of the same species in the vertebrate line from fish up to man in the amount and efficiency of voluntary service to offspring. Some sunfish, for example, will fight courageously to protect their rude nests, others are very timid. Some birds, though trembling with fright, will continue to sit upon and protect their eggs even when threatened with death, while other individuals of the same species desert their eggs or young upon the least approach of danger. The lower races of man, likewise, show their inferior stage of development most forcibly in the insufficient food and care they give to wife and children.

As we glance backward over the history of the earth from the present Cenozoic Era, through the Mesozoic and Paleozoic, we see that compulsory srvice was ever present; that many millions of years ago in the lowest Paleozoic the grosser kinds alone existed; that gradually through the succeeding ages higher types of compulsory service appeared, existing side by side with the grosser; that, finally, voluntary service evolved, and, developing very slowly, reached a degree worthy of the name only in the Cenozoic. These various types of service continued to exist side by side; and since it was the more highly evolved plant or animal group that exhibited the correspondingly high type of service these occupied the better regions of the earth, forcing the less highly developed to less desirable habitats.

That the consumption of other organisms for the prolongation of one's own life extends from the present to the early periods of earth history not only the testimony of tooth structure, claws, tentacles and other food-capturing organs testify, but a multitude of actual records prove. Skeletons of marine reptiles (Plesiosaurs) are abundant in the Mesozoic era, which show in the region of the body where the stomach was formerly situated, the crushed cells of pelecypods and ammonites, the internal skeletons of squids and the broken bones of flying reptiles. In the living chamber of fossil cephalopods also occur at times the hard shell and scale remnants of the diet of these animals; these are found from the lower Paleozoic to the present. The appearance of fish scales in the living chamber of lower Paleozoic individuals testifies to the welcome they gave the earliest fishes upon this earth.

Besides this gross type of compulsory service there was present by

mid-Paleozoic time the forced yielding of the parent's life for the production of young. There were probably many protozoons of which this was true, as it undoubtedly was of many corals whose remains have been preserved, as well as of the many herb-like plants with a single growing season. It was, on the whole, the lower plant or animal groups only whose life span was thus reduced; to the higher groups a longer life was a necessity. Such higher individuals had been evolved by mid and upper Paleozoic time and these were compelled to prepare a considerable amount of nourishment for the developing embryo. This was true of the primitive seed-plants, as well as of the early fish, amphibians and reptiles.

If we may judge by the most nearly related living forms, there must likewise have been present during the entire Paleozoic a rudimentary kind of instinct, with but a minimum amount of free choice and hence of voluntary service. Even the insects, first appearing in the upper Paleozoic and rapidly becoming so numerous in the vast coal-swamps of that time, all belonged to the lower orders with a very low degree of instinct.

With the evolution in the Mesozoic era of the higher seed-plants, insects and fish, and of the most primitive birds and mammals, a higher type of compulsory service was initiated and a distinct beginning in voluntary service made. The higher seed-plants, typified by the oak and hickory, furnished a larger amount of embryonic nutriment and better seed protection than did the primitive seed-plants of the upper Paleozoic. The development of bees, ants and wasps with the mid-Mesozoic was most probably accompanied with a beginning of that wonderfully evolved instinct and of some voluntary service to their young, as well as to the members of the community, which characterize their modern representatives. The incoming at the same time of the highest order of fishes, the Teleostei, may likewise have been accompanied in some individuals, as it is in many of their living descendants, by a certain amount of voluntary service.

Some of the Mesozoic mammals, allied to the existing monotremes, probably like these laid eggs, hatched them as birds now do and then suckled the young; while others, more nearly related to the kangaroos and insectivores were, in all probability, like their modern representatives, forced to protect and nourish the embryo within the body until well developed and after birth to continue this care by fighting off enemies and nursing the young. While all the service before birth, and much after it, was compulsory there still remained a distinct amount of voluntary service both in hatching the eggs and in feeding and protecting the offspring.

During the Cenozoic appeared the highest forms of service, both

compulsory and voluntary, yet developed on the earth. The production of conspicuous flowers, of nectar and other devices for the perpetuation of species of plants is a form of compulsory service originating mostly during the Cenozic, though undoubtedly some of these devices received their inception in the Mesozoic.

The development in the Cenozoic of the living groups of birds was accompanied, if it did not originate in the Mesozoic, with the hatching instinct. A considerable amount of this instinct is, however, voluntary service, since it differs so greatly among individuals of the same species or variety. After the young are hatched the parents are doubtless compelled by instinct to feed and protect them, but here again much of the service is without doubt voluntary. (Since the birds of the Mesozoic were reptile-like in the sharp teeth, claws upon the wings and long vertebrated tail possessed by most individuals, they may also have been reptile-like in their failure to personally hatch their eggs and feed and protect the young.)

The appearance of carnivore, rodent and hoofed mammals in the lower part of the Cenozoic initiated a much higher type of voluntary service. These mammals, to judge by their nearest living relatives, were compelled to serve their young before birth by interuterine nourishment and after birth through the secretion of milk. They also protected their young as well as their mates, and procured them solid food. They were doubtless impelled to these latter acts by instinct, but a considerable amount of voluntary service was present.

In the upper part of the Cenozoic appeared man, and with him began the development of the highest type of voluntary service yet evolved upon this earth. Slowly, extremely slowly, it advanced at first and was for long doubtless limited to the family; gradually, however, it was extended to other members of the clan, nation, language and finally even to the barbarian, heathen or gentile, and even to lower animals and to plants. Man is, however, still under the law of compulsory service. The unborn young must still be given interuterine nourishment and the young child food and care, while public opinion and man-made laws force the laggard to duties which he is not yet sufficiently evolved to perform voluntarily.

We thus see that the development of life upon this earth was due to mutual service, that without such service no higher forms of life could have evolved. Animals can live only through the death of other animals or of plants. Both animals and plants are compelled to give of their strength, or often of life itself, in the production of young. As animals and plants became more highly evolved they developed a higher type of service, that of furnishing more nourishment and better protection to their offspring. Very gradually, side by side with the higher kinds of

compulsory service, there was evolved a voluntary service; minute in kind and amount at first, it has finally come in the nobler members of mankind to dwarf the former by comparison into insignificance. Pre-Paleozoic time and the long Paleozoic era stand for low types of compulsory service; the Mesozoic for higher kinds of compulsory service with a definite beginning of voluntary service, while during the Cenozoic this latter type increased in amount until at present in man it far overshadows the service of compulsion.

Evolution as we see it upon this earth has thus occurred through each successively higher group, taking more and more from others, especially from parents, and giving more and more in return, especially to offspring; the service rendered is passed on, not returned. When, however, a plant or animal group takes more and more from others without giving aditional service in return, we have parasitism, and parasites are not now, nor were they in the distant past, in evolving lines. Parasites whether plant, beast or human are degenerate; the individuals become weaker and weaker and finally the life ends in death.

The trend of evolution has thus been from compulsory service to voluntary, from an enforced aid to others to help given because of love for others. Those lives develop most rapidly and nobly which most nearly conform to this trend.

THE RELATION OF HEREDITY TO CANCER IN MAN AND ANIMALS

By C. C. LITTLE

CANCER COMMISSION OF HARVARD UNIVERSITY

THE existence of hereditary tendencies or predispositions to cancer, in man, has been for years and still is a much debated question. In the face of a steadily increasing volume of evidence both *pro* and *contra,* not only laymen, but the medical profession as well are still of uncertain or divided opinions. Gradually, however, medical institutions have taken up the investigation of the problem until at present a considerable number of laboratories are engaged in experimental studies to determine the importance of heredity in the transmission of cancer. Because of this fact it may be of interest to consider broadly the relation of present genetic methods to the problem of human cancer. We may do this in the hope of determining in advance, if possible, the necessary limitations in applying such methods to the problem in question.

Two main lines of research in genetics may contribute data which have a definite bearing on the question as to whether or not there are hereditary tendencies to cancer in man. The first of these is a study of family histories in human beings themselves; the second is the experimental study of inheritance in the lower mammals.

The value of any data obtained must obviously be based on its scientific accuracy and on its applicability to the problem under consideration. We may now briefly consider the obtainable data in the two branches of research indicated and apply to them the test of value, above mentioned.

All data involving several generations of human beings are of necessity, under our present methods, based at least partly on "hearsay" evidence. The amount of data so obtained when compared with those obtained by direct observation will of course vary in different individual problems. It will, however, always be present as a source of fundamental inaccuracy.

There are many other minor, but none the less important, sources of error. Among these may be mentioned ignorance as to the exact cause of death or diagnoses based on clinical rather than autopsy data. Failure to give sufficient prominence to age, as an important factor, may further complicate the problem. Numerous similar conditions combine with those mentioned to make the data gathered from available sources entirely unreliable in determining the course of inherited tendencies to cancer in the human race.

The accuracy of the data obtained from experimental studies of the

smaller mammals is, on the other hand, sufficient to warrant reliance being placed upon them. Among the smaller mammals, none appear to offer material so favorable to the problem in question as do mice. Their short life cycle, rapidity of multiplication, convenient size and adaptability are supplemented by a varied and representative series of neoplasms serving to give them a unique value. Such studies as those of Tyzzer and Murray, and more recently those of Slye, Loeb and Lathrop, *have proved beyond question that hereditary factors play an extremely important part in determining the incidence of cancer in mice.* Though the *fact* of inheritance is undoubtedly established, *the method of inheritance* is as yet undetermined. Doctor Slye's work has repeatedly shown that non-cancerous parents may give cancerous offspring, and that cancerous parents may give non-cancerous offspring. This at once indicates a complicated type of inheritance, the exact nature of which is still in doubt.

Even in the case of inoculated tumors in mice, where our sole concern is *growth* of the tumor after its implantation, we have recently found that the interaction of many hereditary factors is involved (Little & Tyzzer, 1915).

Although smaller animals, as shown above, possess great advantages over man as material for studying the influence of heredity on the occurrence of spontaneous cancer, they, nevertheless, because of the fact that they are commonly genetically heterogenous, and because cancer is a disease influenced by sex and by the age of the animal, are not free from certain inherent limitations which make the analysis of the hereditary factors, beyond a certain point, extremely difficult. The only possible exception to this statement will be a race of animals so closely inbred as to be essentially homogeneous in its hereditary constitution. Various geneticists as, for example, Pearl and Jennings, have computed with accuracy the amount of inbreeding necessary before such a condition of homogeneity is closely approached. From their work it appears that many generations of continuous closest inbreeding, such as, for example, own brother and sister matings, must be made before homogeneity of genetic constitution is approximated. It is safe to say that none of the material thus far employed in investigations with spontaneous tumors meets this requirement.

Some doubt has been expressed as to the applicability of the results obtained with small mammals such as mice, for example, to the problem of human cancer. In so far as these results may affect the acceptance of the *fact of heredity,* doubts are not justified by analogy with any of the cases of inheritable characters, so far investigated. It is possible and permissible to argue the existence of hereditary tendencies to cancer in man on the basis of proved existence of such tendencies in other mammals. Similar arguments have been shown to apply to albinism, spotting, shape of hair, color of eyes, certain abnormalities in growth of the bones, and to many other characters.

It further appears that certain histories of human families are striking enough, even with present imperfect methods of obtaining data, to indicate strongly the presence of hereditary tendencies to cancer in man. Not only is this the case, but the problem may be approached from the opposite viewpoint and the data supposed to show the non-inheritable nature of human cancer may be examined. Such work as that of Pearson, and other biometricians, while adding little in accuracy to the methods of obtaining data on human inheritance, are guilty of a gross mistake in their method of analysis. Their weakness lies in the fact that they are able to detect only the direct or Galtonian type of inheritance and are utterly unable to recognize or utilize the well-defined and accepted principles of transmission by individuals of hereditary potentialities throughout an indefinite number of generations without any morphological manifestation of those potentialities until similar or otherwise suitable mates appear. Biometrical methods are of undoubted value, but they fall short of the whole truth, and can not in this case be taken as alone disproving the occurrence of hereditary factors in the case of human cancer.

An example of an actual case of inheritance in mice may serve to make clear the limitations of biometric methods of detecting even the fact of inheritance. All pigmented mice are classifiable into two groups, those having solid colored or "self" coats, and those having white spots of varying sizes. In other words, the mouse is either "self" or "spotted" *in appearance*. Supposing a mixed population of let us say 15,000 mice, some of which are "self," some "spotted," and let us try to prove that spotting is or is not inherited. Following certain biometric methods we shall consider the parents and grandparents of each spotted mouse as compared with the same ancestral generations of non-spotted ("self") mice.

Any of the following types of ancestry are possible and have actually been *repeatedly* obtained in the laboratory.

Mating	Mouse Observed	Parents	Grand-Parents
(*a*)	Self	Self	Self
			Self
		Self	Self
			Self
(*b*)	Self	Spotted	Spotted
			Spotted
		Spotted	Spotted
			Spotted
(*c*)	Spotted	Self	Self
			Self
		Self	Self
			Self

(*d*) Spotted................	Spotted................	Spotted Spotted
	Spotted................	Spotted Spotted

Between these extreme types of ancestry every possible intergrade has been obtained again and again, so that if we happened by chance to pick matings of the types (*a*) or (*d*), or others approaching them, we should undoubtedly prove the inheritance of spotting to our own satisfaction. On the other hand, if matings (*b*) and (*c*) had happened to have been our experience, we should believe that no such inheritance existed. Generally speaking, a mixed population of spotted animals would form for biometric methods of analysis only confused and inconclusive material on which no conclusion of lasting value could be based.

It has, however, long been known that spotting in mice *is* inherited, and I have recently been able to account for and predict the occurrence of the spotted forms on the basis of the interaction of at least three pairs of hereditary factors showing Mendelian or alternative inheritance. In making the analysis of this problem it was fortunate that in certain races in the laboratory, only one or at most two of the three types of spotting existed together. This fact made possible the recognition of certain relationships between the different types of spotted coat which would otherwise have certainly escaped notice, and without which even an incomplete explanation of the facts would have been impossible.

The case of spotting in mice has been entered into at some length because of the fact that it proves the inadequacy of purely biometric methods to detect or explain a case of heredity even involving as few as three pairs of factors. Moreover, these spotting factors produce a series of forms recognizable in early life, and spotting, unlike cancer, is free from the effects of age, sex or any but the most radical environmental disturbances. To *disprove* inheritance solely by biometric methods in this simple case is impossible, and the same is certainly true in the obviously less simple case of cancer.

If now we turn to a consideration of the human beings as material and of certain facts concerning the biological nature of cancer, we can recognize the handicaps under which we must work, if we attempt to investigate the course of hereditary tendencies to cancer in man.

Biologically, cancer may be considered as consisting of a mass of tissue of local origin manifesting uncontrolled and unlimited growth. The problems of its etiology are therefore essentially those of the factors causing, limiting and directing cell division.

If we for a moment consider the cells of the animal body as units, we can picture the embryo of any mammal, at the gastrula stage, as consisting of essentially *two* types of slightly differentiated cells, ectoderm and endoderm. Each of the two types of cells may figura-

tively be considered as a "species" consisting of a number of "individuals" undergoing reproduction by the process of mitosis. There are two very distinct environmental forces in the life of such an embryo. One we may call the "external environment," as exemplified by the surroundings of the embryo, the other we may call the "internal environment" which includes the relationships between cells (individuals) *within* the embryo. During the gastrula stage the *internal* environment is relatively simple, but as the embryo grows we find that complexities appear one after another. As the number of cells (individuals) increase, we find that the number of *types* of cells (species) increase as well (differentiation of tissues). This may be considered largely the result of differences in the internal environment in which certain cells or groups of cells find themselves. Nutrition, and undoubtedly to a large extent internal secretions, play the leading parts among the influences of the internal environment.

The young mammal shortly before sexual maturity has thus reached a point where a steady process of cell division (multiplication of individuals) within many definite types of tissue (many species) is in progress. Now into this more or less balanced condition is introduced the secretions of the newly active sex glands, ovaries or testes, as the case may be. At once the internal environment is fundamentally changed. By the circulation the modifications introduced by these secretions are transmitted through the body, reaching all types of cells in all localities. It is as though in a given isolated geographic unit, populated by a fauna of many species, a certain food tree was introduced in great numbers in addition to the somewhat similar types of food trees formerly there. This new tree provides food which gives certain species of animals in certain localities more suitable nutrition than they have yet obtained. The result is rapid growth and reproduction of that particular species, while the others near it may be unaffected, or may even suffer by the rapid multiplication of the favored species.

It is obvious that changes in the internal environment will be frequent. The cyclic changes of the reproductive system, including also the changes of pregnancy and of lactation, undoubtedly represent fundamental upsets of the equilibrium of the internal environment. The same, of course, holds for retrogressive changes such as accompany the cessation of activity of the reproductive system and the progressive changes of approaching senility.

To any biologist, it will have long ago suggested itself to question the influence of the inherent physico-chemical nature of the cell material. Undoubtedly this is a matter of fundamental importance, for it is in the reaction of the cells to the influences and agencies of the internal environment that initiation, continuation and control of cell

division have their origin. It is also certain that hereditary differences in the nature of the cell material among animals of a single species exist. These differences will naturally be an important factor in the reaction of such material to a given stimulus of the internal environment. For example, we may imagine that a certain type of internal environment may cause the material within the connective tissue of individual (*a*) to show no abnormality of growth, while the material forming the connective tissue of individual (*b*) of the very same species may be inherently different to a point where an identical internal environment will start up uncontrolled growth.

On the other hand, two individuals may have connective tissue which is similar in respect to its reactions to a certain stimulus of given internal environment *X*, but may differ in their internal environments because of differences in amount or exact chemical nature of internal secretions or other important agents. In one animal, connective tissue *Y* might show no effects of internal environment *X*, while in the other the interrelation of connective tissue *Y* with environment *X′* might lead to uncontrolled growth.

This rather lengthy treatment of the subject of internal environment has for an object to emphasize the extremely complicated biological nature of cancer. Occurring as it does, usually in middle or old age, it is at a point most completely removed in time and space from the carriers of the elementary hereditary tendencies—the germ cells. In such an animal as man, where the average age for the appearance of cancer, broadly speaking, is about forty-five to fifty years, the opportunities for the effects of the internal environment to become excessively amplified and complicated are, of course, obvious. Injury as well as inflammation of long duration, long recognized as probable agents in the initiation of uncontrolled or abnormal growth, are also much more likely to be of importance in a very slow-growing mammal such as man, than in a rapidly growing mammal like the mouse. This follows from the fact that the *critical periods* in internal environmental changes in man are in themselves far longer in duration than they are in mice, and an injury or irritation, therefore, has more chance of occurring in one of these periods. In the cases of irritation or injury the inherited nature of the individual is of prime importance. A great number of men may use tobacco to an equal extent and yet only part of them may develop cancer of the buccal cavity. In such cases the irritating stimulus may be equal, but the nature of the reaction of the individual's tissue may differ widely.

Again and again we are driven back to the ground that the nature of the mouse, or of the man, by which we mean the nature of his hereditary living material, determines his physiological reactions to any given environment, and further we may add that it determines to a

large extent the behavior of the fundamental factors influencing his *internal* environment. As we attempt, however, to analyze the important hereditary factors, we are in man faced with certain limiting facts. Inadequate methods of observation, diagnosis and recording; magnified effects of environment due to a long life cycle; small numbers of young, and a deliberate system of out-breeding which completely mixes and confuses the material with which we have to deal, force us to the conclusion that studies of hereditary tendencies to cancer in man as they are at present carried on, will yield little, if anything, of value to the subject under consideration. We may further say that present indications are that genetic studies with lower mammals, while having proved definitely the existence of hereditary tendencies to cancer, indicate that a complex type of inheritance is involved which could at best be of negligible importance as a practical preventive or protective measure in man.

This may give the erroneous impression that genetic studies even with lower animals are superfluous in the field of cancer research. This would be most unfortunate, however, for it appears certain that the *etiology* of cancer is a problem of growth and differentiation and as such is essentially biological in nature. It may therefore be approached perhaps with marked success, through genetic investigations with rapidly breeding small mammals in which a study of the biological factors fundamentally important can, under proper circumstances, be best accomplished.

THE PROGRESS OF SCIENCE

THE EPIDEMIC OF INFANTILE PARALYSIS

THE epidemic of infantile paralysis centering in Brooklyn has not attracted more attention than it deserves, although the 2,000 cases and 400 deaths which had occurred up to July 18 are not large in comparison with the waste of child life to which we submit. About 200,000 infants and about an equal number of children and young people die needlessly each year in this country. That the deaths are due to ignorance and neglect is evident from the fact that three times as many children die in Fall River and Patterson as in some other cities. It is quite possible that through the vigorous hygienic and sanitary measures now being undertaken in New York City more lives will be saved than are lost through the epidemic.

The disease is startling through its comparative newness, its method of spreading, the futility of any treatment, its symptoms, the high death rate and the permanent after effects which may ensue. The best available account of the nature of the disease, the manner of its conveyance and the means of prevention, is contained in an address given before the New York Academy of Medicine on June 13, by Dr. Simon Flexner, director of the laboratories of the Rockefeller Institute for Medical Research, whose researches have contributed largely to what we know concerning infantile paralysis, or poliomyelitis, and spinal meningitis. Dr. Flexner tells us, in his address, which is printed in the issue of *Science* for July 21, that infantile paralysis is an infectious disease caused by an invasion of the spinal cord and brain by a minute filterable microorganism, which has now been secured in artificial cultures and is visible under the higher powers of the microscope. The virus exists not only in the central nervous organs, but also on the mucous membranes of the nose, throat and intestines. Less frequently it occurs in other organs and it has been found in the blood. The virus can be detected by inoculation tests upon monkeys, though with so much difficulty that ordinary bacteriological tests can not be employed for the discovery of the disease. In this manner it has, however, been determined that healthy persons may carry and spread the infection.

The virus of infantile paralysis leaves the infected patient through the secretions of the nose, mouth and intestines and enters the body as a rule, if not exclusively, by way of the mucous membranes of the nose and throat. Since epidemics of infantile paralysis always arrive during a period of warm weather, they have been thought to be connected with insect life. This has, however, been disproved, except in so far as domestic flies and other insects may serve as mechanical carriers. The paralytic diseases of domestic animals and pets are quite different from infantile paralysis and these animals must be acquitted of being hosts.

Infantile paralysis is one of the diseases in which insusceptibility is conferred by a previous attack and protection has been conferred on monkeys by inoculation with small amounts of the virus and by serum treatment. Promising results are said to have been obtained in France on men but the quantity of human immune serum is very limited and no animal except the monkey seems capable of yielding the immune serum, and the monkey is not a practical animal from which to obtain supplies. The only drug which has shown any useful degree of activity is hexa-

Photograph from Underwood and Underwood, N. Y.

Elie Metchnikoff

The distinguished Russian Zoologist and Bacteriologist, since 1888 a Member of the Pasteur Institute, Paris. He died on July 15, aged seventy-one years.

methylenamin, but in monkeys this has proved effective only very early in the course of the inoculation and only in a part of the animals treated. The epidemic must be controlled by general sanitary means, though medical and surgical care may assist in recovery. Protection can best be secured through the discovery and isolation of those ill of the disease and the control of those persons who have associated with the sick and whose business calls them away from home. The usual means by which the secretions of the nose and throat are disseminated are through kissing, coughing and sneezing. The early detection and isolation of infantile paralysis in all its forms with the attendant control of the households from which they come is the chief measure of staying the progress of the epidemic.

CINCHONA AS A TROPICAL STATION FOR AMERICAN BOTANISTS

PROFESSOR DUNCAN S. JOHNSON, of the Johns Hopkins University, it will be remembered, contributed to the POPULAR SCIENCE MONTHLY (December, 1914, and January, 1915) two illustrated articles on the Cinchona Botanical Station. He now writes to *Science* that it is practically assured that some fourteen American universities, botanical foundations and individual botanists are to cooperate with the Jamaican government in the support of Cinchona as a tropical station. A move to aid in the support of Cinchona, initiated by the Botanical Society of America in 1912, was not consummated, in consequence of the earlier leasing of the station to the British Association for the Advancement of Science. The Jamaican authorities and the British Association seem quite willing, under present conditions, to allow the lease to pass into American hands after October next.

The attention of American investigators should, therefore, be directed to the facilities for botanical research offered by this oldest and best known botanical laboratory in the western tropics. Among the advantages of this station for American botanists are the greatly varied flora and series of types of vegetation; the proximity of a library and of two other botanical gardens, beside that surrounding the laboratory. The location of Cinchona is a very fortunate one for American botanists from a practical standpoint. It is in an English-speaking country with good roads, a stable government and adequate quarantine service. It is also within easy reach of our eastern seaports, from several of which the round trip to Jamaica and Cinchona can be made in summer for $75.00 or less for transportation. It is altogether probable that any American botanist wishing to work at Cinchona will be granted the privilege by requesting it of the colonial government of Jamaica through Superintendent William Harris, F.L.S., Hope Gardens, Kingston, Jamaica.

Dr. C. H. Farr of Columbia University calls attention to the fact that a tropical rain-forest presents peculiar conditions. The plants do not show the marked periodicity characteristic of colder and dryer regions. Where the temperature and rainfall are so nearly constant at all times of the year as at Cinchona, one is likely to find all of the stages in the life history of a species on almost any single day, and conditions are favorable for collecting the year around. To the cytological collector a compound microscope is an absolute necessity; and such a permanent station as that at Cinchona, therefore, seems to be the only solution to the accessibility of such regions. The buildings at Cinchona, including two cottages, a two-room laboratory, the drying house, the dark room, the greenhouses and the garden, were all in good condition when he left there in December last. Through the kind offices of Mr. William Harris at Hope Gardens servants were made available, and his personal needs adequately

supplied. The space is sufficient for a number of investigators at one time, and life there is very pleasant indeed.

Dr. Forrest Shreve of the Desert Laboratory of the Carnegie Institution writes that the portions of the Blue Mountains which are accessible from Cinchona, at both higher and lower altitudes, exhibit a diversity of vegetation in correlation with the widely differing temperature and moisture conditions, and also a vertical diversity from floor to canopy within the rain-forest itself. Ample opportunity is thus offered for the investigation of the physical environment in relation to the local and general distribution of plants. A wide range of plant material is available for the study of general physiological behavior as well as for the special types of activity characteristic of rain-forest plants. The fundamental processes of plants, as carried on under extremely humid conditions, and the influence of the character and rate of these processes upon the growth, distribution and periodic phenomena of the hygrophytic vegetation offer a rich field for future work at Cinchona. The gardens, greenhouses and various outbuildings afford opportunity for propagating plants and for placing them under a variety of experimental conditions. The nearness of an extensive tract of virgin forest is also a valuable asset for physiological as well as ecological work. The excellent trails, the easy means of communication and supply, the presence of a guide with a knowledge of the local flora, and the very healthful living conditions combine to make Cinchona an extremely useful station for those who may wish to carry on more or less prolonged investigations in the problems of the semi-torrid and humid tropics.

IRRIGATION IN BRITISH COLUMBIA

One of the strongest conservation fights in all America is being waged in British Columbia where the destruction of the forests on the Rocky Mountain slopes through continual fires has imperilied many thousands of acres of farm land in the valleys. Hand in hand with these efforts of the provin-

An Irrigation Flume in British Columbia. Summerland District.

Application of the Water to the Trees, showing Method of Irrigation. The water is generally put on to the highest point of an orchard by the company and from there the fruit farmer distributes it all over his orchard, as shown in this photograph.

A Valley Reclaimed. Summerland District of British Columbia under irrigation.

cial government is the work of the irrigation companies, which number nearly three hundred in the province; most of them, of course, control only a few miles of pipe lines and have a low capitalization. The largest irrigation project in Canada is at Bassano, Alberta, and in it the Canadian Pacific Railway has already invested $10,000,000. Whatever the dimensions of the company, however, the fact that its revenues depend upon a supply of water from the hills and the additional fact that stripping the hills of timber growth ruins the water supply, brings to the side of forest protection a very strong influence.

In the interior of British Columbia, from which the accompanying photographs were taken, irrigation has reached a high degree of perfection. Barren lands were bought up by companies at a few dollars an acre and resold at a thousand dollars an acre. Those who have bought at these prices have in numbers of cases made large profits from fruit cultivation. The growth of fruit trees and of the fruit is very rapid because of the steady supply of moisture, although the quality of the product is regarded by many as not quite equal to that of non-irrigated lands.

SCIENTIFIC ITEMS

DR. CHARLES HORACE MAYO, of Rochester, Minn., was elected president of the American Medical Asociation at the recent Detroit meeting. Dr. William J. Mayo, his brother, was president in 1906.—Dr. Henry M. Howe, emeritus professor of metallurgy in Columbia University, has been appointed honorary vice-president of the Iron and Steel Institute of Great Britain.—At a meeting of the Texas chapter of the Society of the Sigma Xi, on June 5, Dr. Frederic W. Simonds, professor of geology in the University of Texas, was elected president for the year. Dr. Simonds was one of the first five graduate students elected to membership in the Cornell chapter.

THE International Health Commission of the Rockefeller Foundation, sent to Brazil to make a general medical survey of the southern part of the country, has returned. The commission consisted of Professor Richard M. Pearce, of the University of Pennsylvania, chairman; Major Bailey K. Ashford, of the U. S. Medical Corps; Dr. John A. Ferrell, of the International Health Commission, and a secretary. They were absent for about four months and the work included a study of the general educational system in Brazil, the medical schools, hospitals and dispensaries, and public health organization.—The Carnegie Institution expedition to Tobago, British West Indies, was exceptionally successful. The southwestern end of Tobago consists of elevated coral-bearing limestones and the coast from Milford Bay northward is flanked by a modern coral reef. Dr. Hubert Lyman Clark, of Harvard University, collected 73 species of echinoderms in this region, and of these Dr. Th. Mortensen, of Copenhagen University, reared 10 throughout their larval stages; among them a crinoid Tropiometra which was abundant over the shallow reef-flats. Dr. A. G. Mayer studied the Siphonophores, the pelagic life being abundant, due to the fact that the water of the great equatorial drift of the Atlantic strikes immediately upon the coast of Tobago. The coastal waters of Tobago are those of the clear blue tropical ocean, for the island lies to the northward of the muddy shores of Trinidad.